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Interim Bioventing Pilot Test Results Report for Building 8200 Fort Carson, Colorado

Prepared For



**The US Army Environmental Center
Aberdeen Proving Ground, Maryland**

**Fort Carson
Colorado Springs, Colorado**

and



**Air Force Center for Environmental Excellence
Brooks Air Force Base
San Antonio, Texas**

November 1996



**PARSONS
ENGINEERING SCIENCE, INC.**

1700 Broadway, Suite 900 • Denver Colorado 80290

AGM01-03-0588

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**INTERIM BIOVENTING PILOT TEST RESULTS REPORT FOR
BUILDING 8200**

**FORT CARSON
COLORADO SPRINGS, COLORADO**

Prepared for:

**US Army Environmental Center
Aberdeen Proving Ground, Maryland**

Fort Carson, Colorado

and

**Air Force Center for Environmental Excellence
Brooks AFB, Texas**

November 1996

Prepared by:

**Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, CO 80290**

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INTERIM BIOVENTING PILOT TEST RESULTS REPORT FOR BUILDING 8200 FORT CARSON, COLORADO

1.0 INTRODUCTION

An initial bioventing pilot test was performed by Parsons Engineering Science, Inc. (Parsons ES) at Building 8200 at Fort Carson, Colorado during the period from July 15 through August 7, 1996. The proposed scope of work for this site was performed for Fort Carson, the US Army Environmental Center (USAEC), and the Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division (ERT) under AFCEE contract F41624-92-D-8036, Order 0017. The purpose of this report is to describe the results of the initial pilot test at Building 8200 and to make recommendations for extended testing and full-scale system installation to determine the long-term impact of bioventing on site contaminants. Descriptions of the history, geology, and contamination at Building 8200 are presented in the bioventing pilot test work plan (Parsons ES, 1996).

The sources of vadose zone soil contamination at this site were four former 20,000-gallon underground storage tanks (USTs) that were used to store gasoline and diesel fuel [Rust Environmental & Infrastructure (RUST), 1994]. The tanks were removed by Parker Excavating during November 1996 (Cloonan, 1996a). Full-scale bioventing system installation is expected to occur in early 1997.

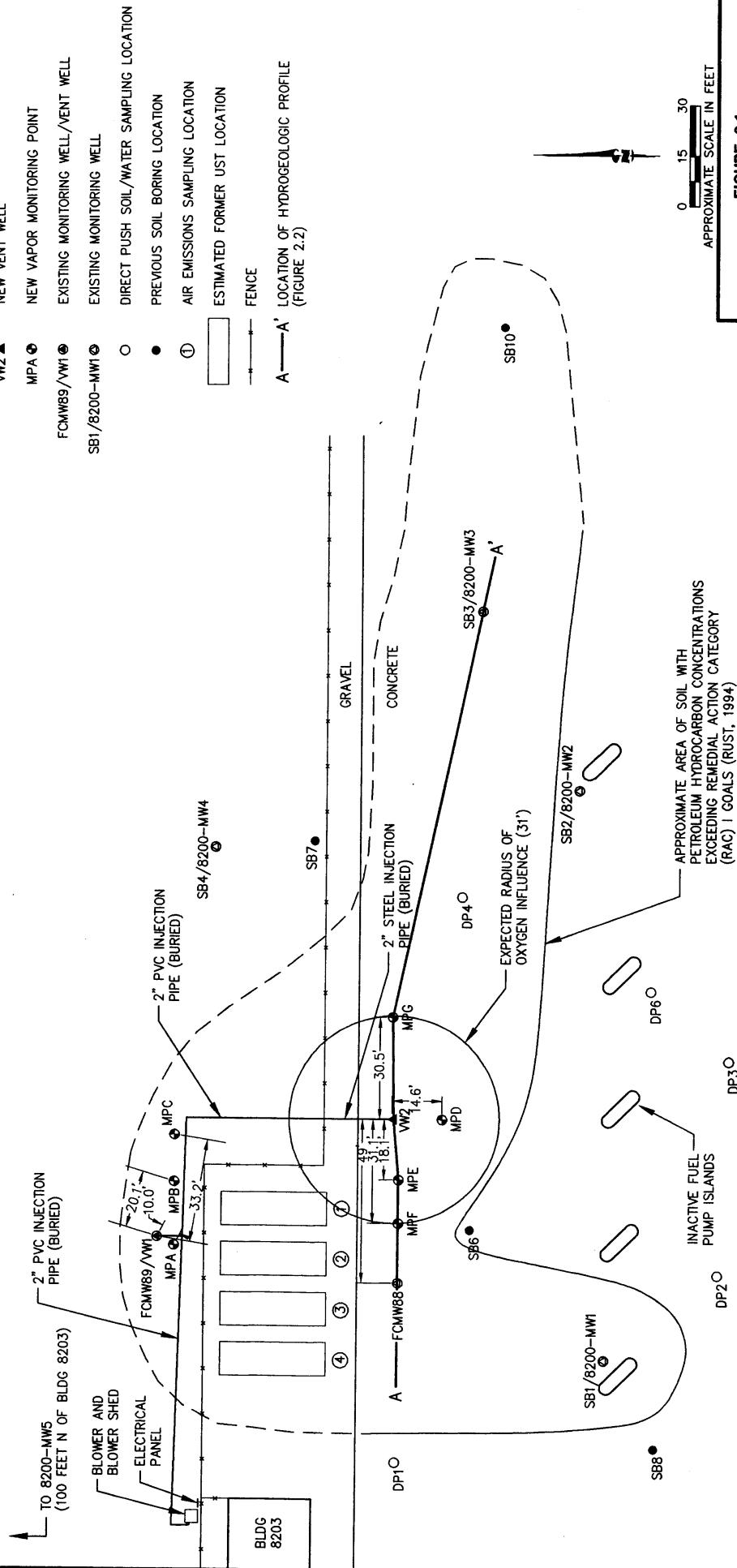
2.0 PILOT TEST DESIGN AND CONSTRUCTION

A total of four Geoprobe® boreholes were installed by Parsons ES at the site to better define the extent of contamination, and to determine appropriate vapor monitoring point (MP) screen depths. Vapor MPs MPA, MPB, MPC, and MPG were installed by Parsons ES in Geoprobe® boreholes on July 16, 17, 18, and 26, 1996. Installation of an air injection vent well (VW) (VW2) and three additional vapor MPs (MPD, MPE, and MPF) using auger drilling methods took place on July 22 through 24, 1996. Drilling services were provided by Ground Exploration Company, Inc. of Arvada, Colorado, and VW and MP installation and soil sampling was directed by Mr. David Teets, the Parsons ES site manager. Electrical services were provided by Herb Wilson Electric, and concrete repair was completed by AAA Concrete, both of Colorado Springs, Colorado.

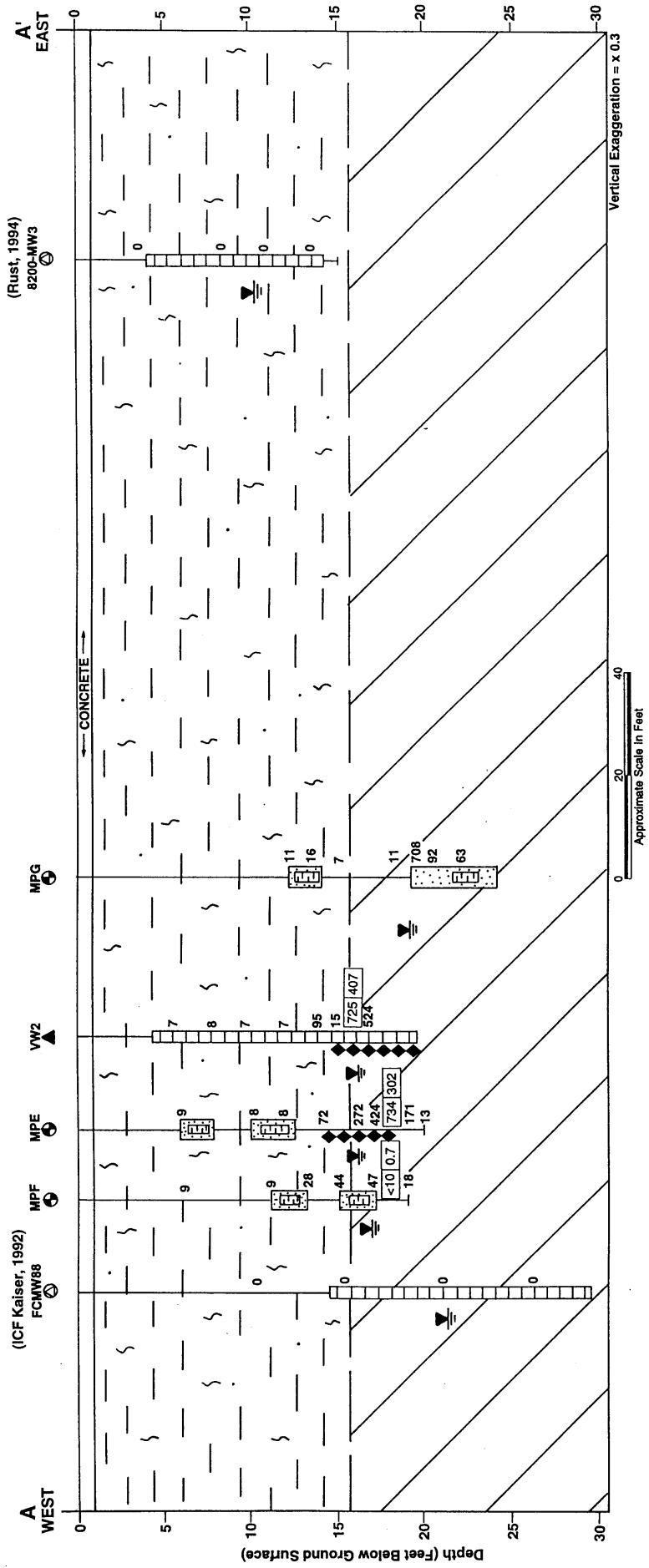
In addition to VW2 and the seven MPs (MPA through MPG), a blower unit was installed at the Building 8200 site. Existing monitoring well FCMW89, installed by ICF Kaiser Engineers (ICF Kaiser, 1992), also was used as a VW (VW1), and wells FCMW88, 8200-MW1, -MW2, and -MW3 were used as MPs. Figure 2.1 is a site layout showing the locations of the two VWs, seven new MPs, blower unit, existing groundwater monitoring wells, and previous soil borings at the site. The hydrogeology of the site is depicted in the cross-section on Figure 2.2. Borehole logs for the MPs and VWs are included in Appendix A. The background MP for this site was existing groundwater monitoring well 8200-MW5, which is screened several feet above the

LEGEND

VW2 ▲	NEW VENT WELL
MPA ◊	NEW VAPOR MONITORING POINT
FCMW89/VW1 ◊	EXISTING MONITORING WELL/VENT WELL
SB1/8200-MW1 ◊	EXISTING MONITORING WELL
SB1/8200-MW1 ◊	DIRECT PUSH SOIL/WATER SAMPLING LOCATION
●	PREVIOUS SOIL BORING LOCATION
①	AIR EMISSIONS SAMPLING LOCATION
□	ESTIMATED FORMER UST LOCATION
—+—+—	FENCE

**FIGURE 2.1****AS-BUILT SITE PLAN**Building 8200
Fort Carson, Colorado**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado



LITHOLOGIC DESCRIPTION

S.S. CLAY, SILTY, SOME SAND W.S.B. WEATHERED SILTSTONE BEDROCK

LEGEND

- Vent Well (▲)
- Vapor Monitoring Point (MPF)
- Existing Monitoring Well (FCMW88)
- Field Screening Result for Volatile Organic Compounds (ppmv)

734 302 LABORATORY RESULT FOR
TEPH/TPH (mg/kg)

725 407

524

272

72

95

15

11

16

7

11

708

92

63

0

GEOLOGIC CONTACT
DASHED WHERE INFERRED

MONITORING POINT SCREENED
INTERVAL AND SAND PACK INTERVAL

SCREENED INTERVAL

FIGURE 2.2

HYDROGEOLOGIC CROSS-SECTION

Building 8200
Fort Carson, Colorado

**PARSONS
ENGINEERING SCIENCE, INC.**
Denver, Colorado

groundwater surface. Well 8200-MW5 is located approximately 100 feet north of Building 8203. The following sections describe the final design and installation of the bioventing system at Building 8200.

2.1 Air Injection Vent Well

The new air injection VW (VW2) was installed in highly contaminated soils approximately 25 feet southeast of the USTs, within the concrete-covered area (Figure 1.1). The VW was constructed using 4-inch-diameter, Schedule 40 polyvinyl chloride (PVC) casing and 0.02-inch slotted PVC screen. Table 2.1 summarizes the VW construction details. The total depth of the VW is 19.5 feet below ground surface (bgs), with the screened interval extending from 4.5 to 19.5 feet bgs. The annular space between the well casing and borehole was filled with 8-12 silica sand from the bottom of the borehole to approximately 6 inches above the top of the well screen. Granular bentonite was placed above the sand, and hydrated in place with potable water. The top of the well was completed with a 12-inch-diameter flush-mounted well box mounted in a rectangular concrete pad. Construction details for VW1 (Well FCMW89) and VW2 are presented on Figures 2.3 and 2.4, respectively.

2.2 Monitoring Points

The MP screens were installed at the depths listed on Table 2.1. The seven multidepth MPs (MPA, MPB, MPC, MPD, MPE, MPF, and MPG) at this site were constructed as shown in Figures 2.5 and 2.6. Monitoring points MPA, MPB, MPC, and MPG were installed in Geoprobe® borings, and are constructed with a 6-inch-long, 0.375-inch outside-diameter (OD) stainless steel screen implant attached to 0.5-inch-OD, high-density polyethylene (HDPE) tubing that extends to the ground surface. The top of each 0.5-inch HDPE riser was completed with a 3/8-inch needle valve (Figure 2.5).

Monitoring points MPD, MPE, and MPF were installed in auger-drilled borings and were constructed using 6-inch sections of 1-inch-diameter PVC well screen with 0.25-inch-diameter PVC riser pipes extending to the ground surface. At the top of each riser, a ball valve and a 3/16-inch hose barb were installed. The top of each MP was completed with a flush-mounted metal well protector set in concrete. Thermocouples were installed at the 12- and 16-foot depths at MPF to measure the soil temperature profile at the site (Figure 2.6).

Soil gas samples could not be collected from several of the MP screened intervals (MPB-15.5, MPB-20, MPC-15, MPC-23, MPE-11, MPF-16, and MPG-22) due to perched groundwater or impermeable soil conditions. Future MP screens should be installed within a 3-foot sand pack interval to increase the MP surface area. The existing groundwater monitoring well 8200-MW5 was used as the background MP for this pilot test. 8200-MW5 is located in an uncontaminated area approximately 100 feet north of Building 8203 (Figure 2.1) and has a screened interval extending above the groundwater surface (Appendix A).

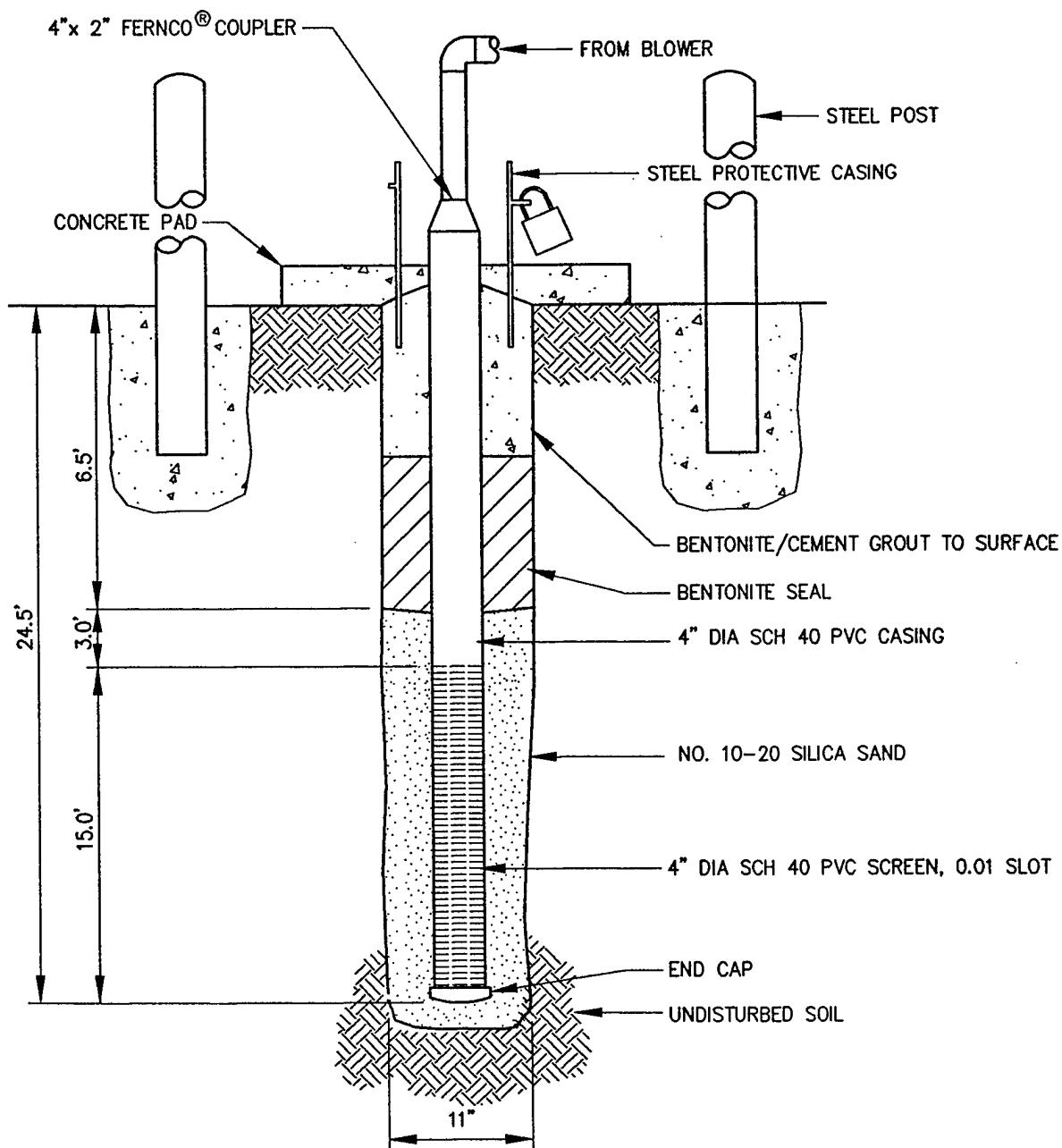
TABLE 2.1
VENT WELL AND MONITORING POINT CONSTRUCTION SUMMARY
BUILDING 8200
FORT CARSON, COLORADO

Location	Total Borehole Depth (feet bgs) ^{a/}	Screened Interval (feet bgs)	Sand Pack Interval (feet bgs)
FCMW88	30.0	14.5-29.5	10.5-30.0
FCMW89 (VW1)	25.0	9.5-24.5	6.5-25.0
8200-VW2	19.5	4.5-19.5	4.0-19.5
8200-MPA	22.0	16.0, 19.0	15.5-16.5, 18.5-19.5
8200-MPB	22.0	15.5, 20.0	15.0-16.0, 19.5-20.5
8200-MPC	24.0	15.0, 23.0	14.0-16.0, 22.0-24.0
8200-MPD	20.5	10.0, 18.0	8.0-12.0, 16.0-20.5
8200-MPE	20.0	7.0, 11.0	6.0-8.0, 10.0-12.5
8200-MPF	19.0	12.0, 16.0	11.0-13.0, 15.0-17.0
8200-MPG	24.0	13.0, 22.0	12.0-14.0, 19.0-24.0
8200-MW1	20.0	5.8-15.8	3.3-20.0
8200-MW2	18.5	7.6-17.6	6.0-18.5
8200-MW3	15.0	4.1-14.1	3.0-15.0
8200-MW4	17.3	6.8-16.8	3.0-17.3
8200-MW5 (BKGRD MP)	22.6	12.1-22.1	3.0-22.6

^{a/} bgs = below ground surface.

Note: Monitoring points MPA, MPB, MPC, and MPG were installed in Geoprobe® borings.
 Vent well VW2 and monitoring points MPD, MPE, and MPF were installed in auger borings.
 Monitoring wells FCMW88 and FCMW89 installed by ICF Kaiser (1992).
 Monitoring wells 8200-MW1, -MW2, -MW3, -MW4, and -MW5 installed by RUST (1994).

MONITORING WELL FCMW89



NOT TO SCALE

FIGURE 2.3

**MONITORING WELL FCMW89
(VW1) CONSTRUCTION DETAIL**

Building 8200
Fort Carson, Colorado

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

Source: ICF Kaiser, 1992

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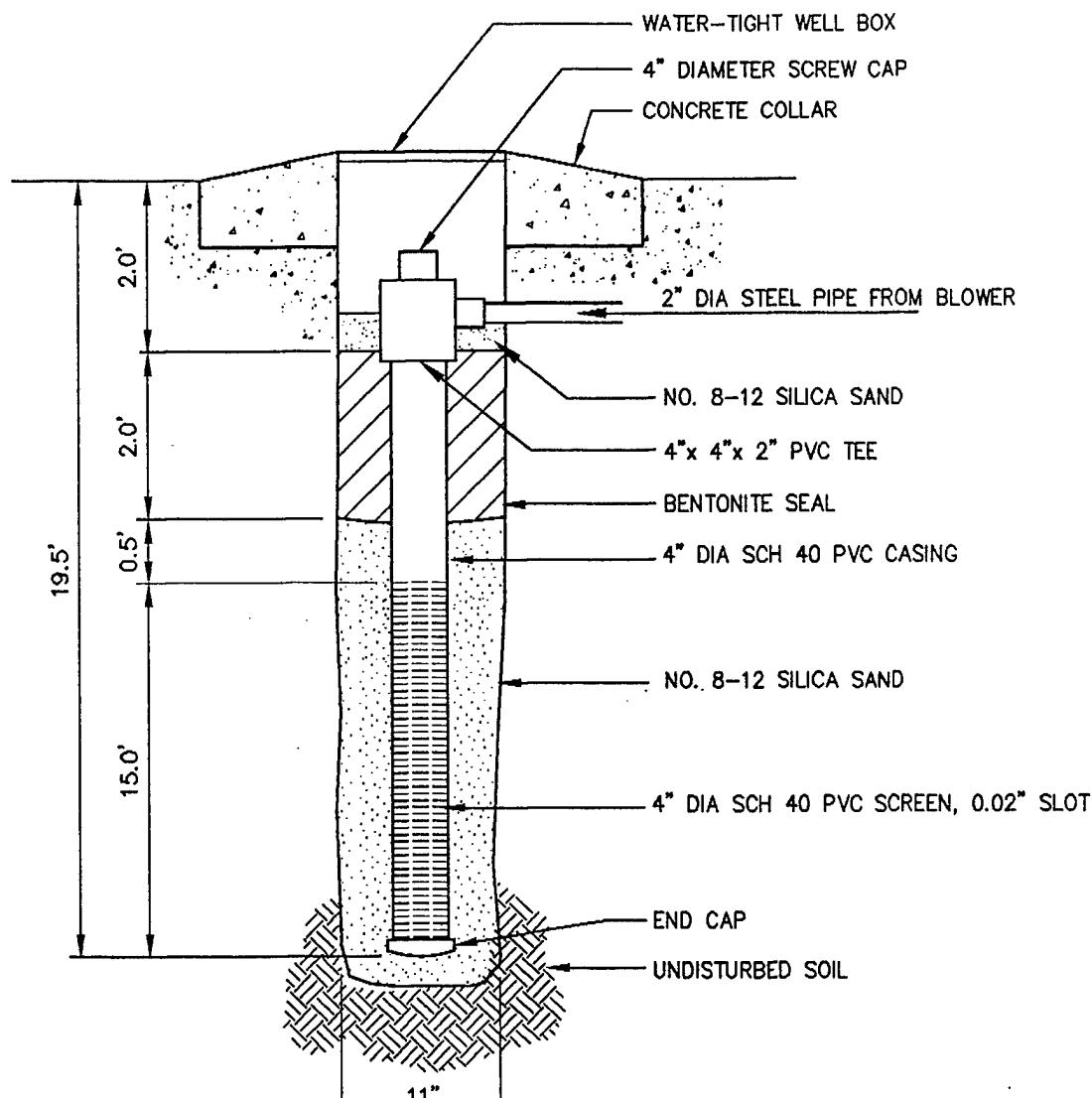
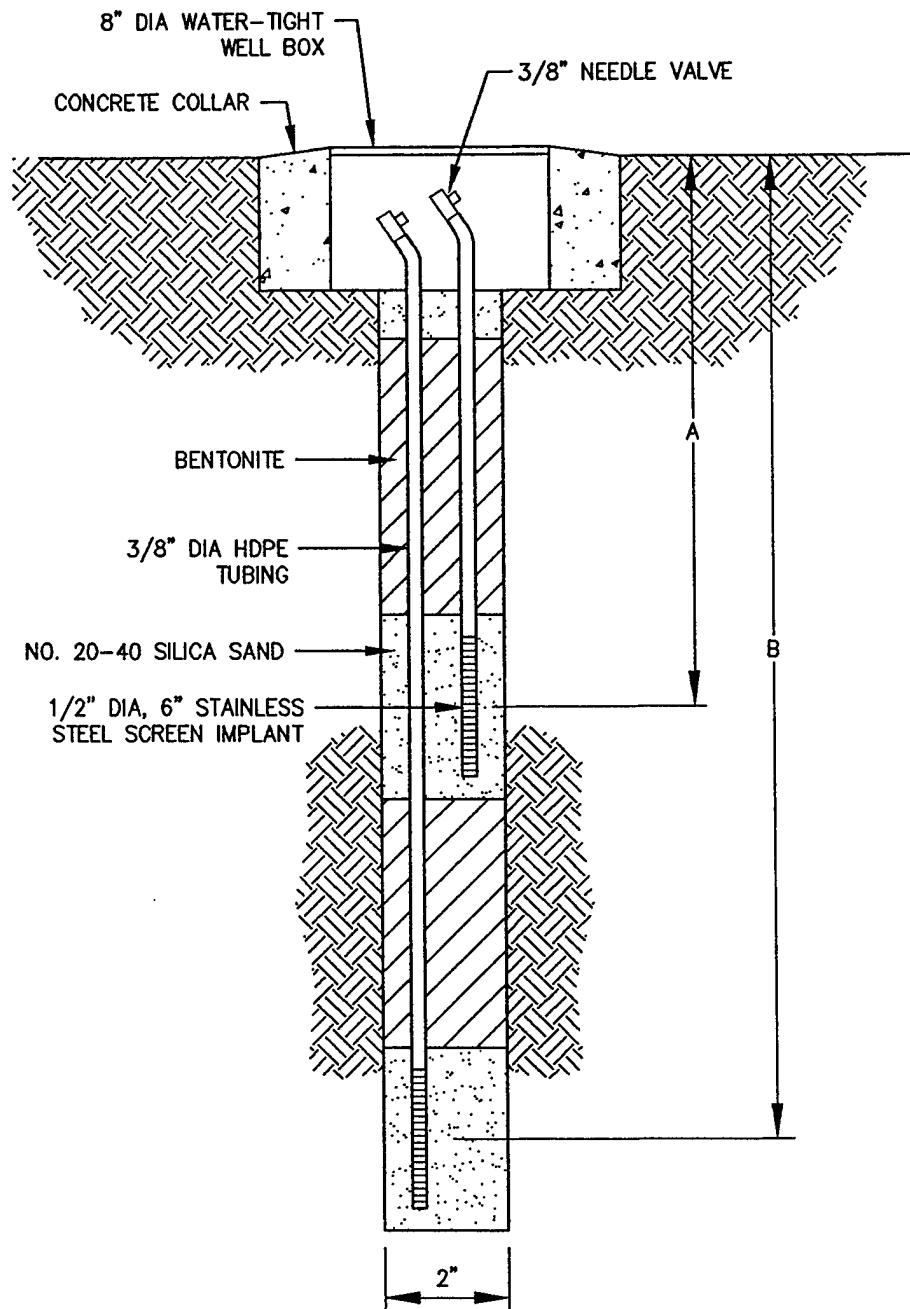


FIGURE 2.4
AS-BUILT
INJECTION VENT WELL VW2
CONSTRUCTION DETAIL

Building 8200
Fort Carson, Colorado

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado



MONITORING POINT	DEPTH TO SCREENED INTERVALS (ft bgs) ^a	
	A	B
MPA	16.0	19.0
MPB	15.5	20.0
MPC	15.0	23.0
MPG	13.0	22.0

a/ ft bgs = FEET BELOW GROUND SURFACE

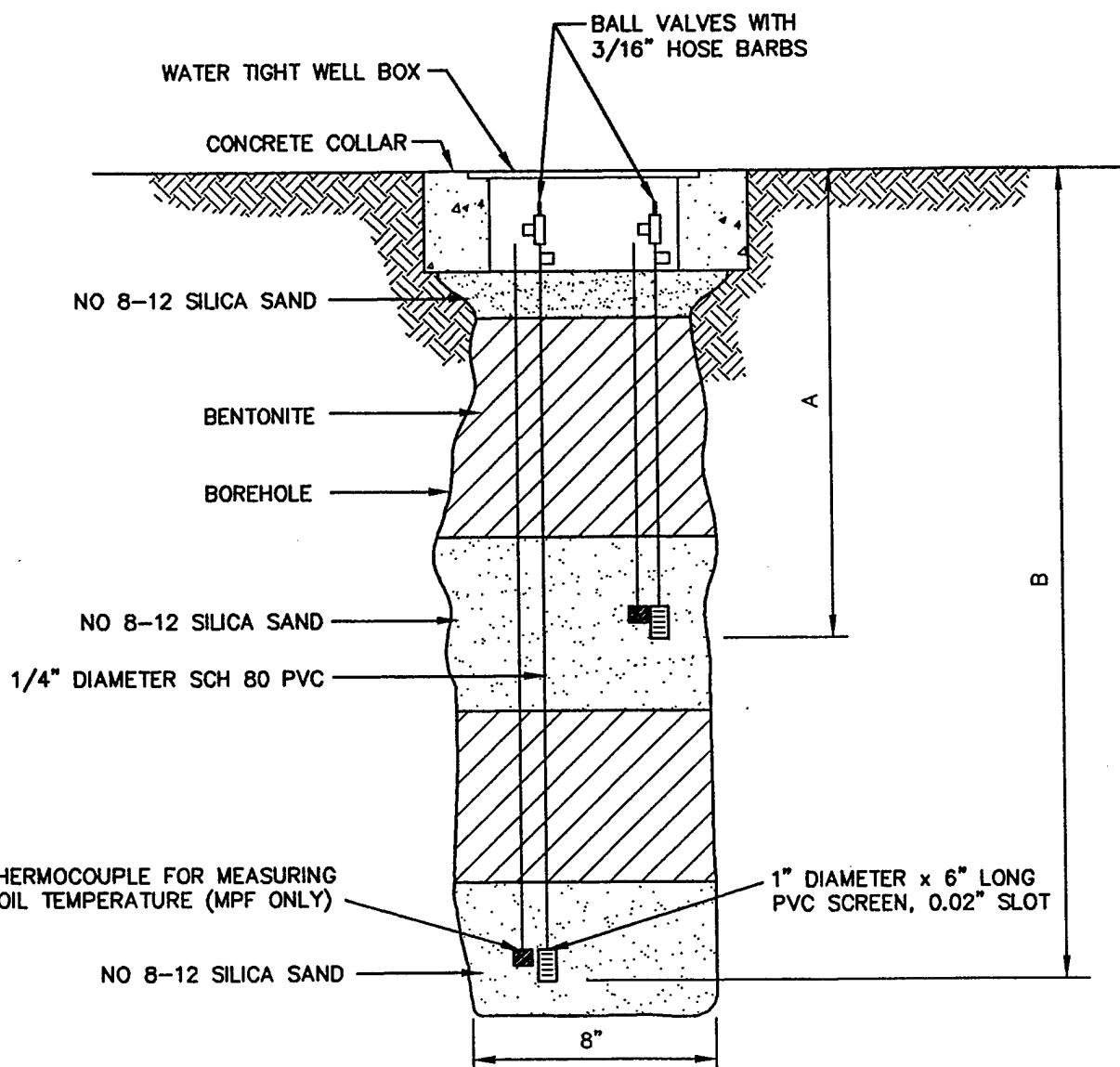
FIGURE 2.5

**AS-BUILT GEOPROBE®-INSTALLED
MONITORING POINT
CONSTRUCTION DETAIL
(TYPICAL)**

Building 8200
Fort Carson, Colorado

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado



NOT TO SCALE

MONITORING POINT	DEPTH TO SCREENED INTERVALS (ft bgs) ^a /	
	A	B
MPD	10.0	18.0
MPE	7.0	11.0
MPF	12.0	16.0

a/ ft bgs = FEET BELOW GROUND SURFACE

FIGURE 2.6

AS-BUILT AUGER-INSTALLED MONITORING POINT CONSTRUCTION DETAIL (TYPICAL)

Building 8200
Fort Carson, Colorado



**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

2.3 Blower Unit and Piping

A 2-horsepower Gast[®] regenerative blower unit was installed at Building 8200 for use in both the initial and extended pilot tests. The blower is energized by 230-volt, single-phase, 30-amp line power from a new distribution panel located on a new electrical panel installed adjacent to Building 8203 (Figure 2.1). The pilot test blower injected air into the subsurface at approximately 17.5 standard cubic feet per minute (scfm) for each of the three initial tests (at VW2, FCMW88, and FCMW89), and the injection flow rate was optimized at 13 scfm for each VW1 and VW2 for the extended pilot test. The final blower wiring was completed on July 18, 1996, and the system started on August 5, 1996. On November 22, 1996 it was discovered that the blower was not in operation. Upon restarting the blower, the blower pressure was set at 40 inches of water (Cloonan, 1996b). The blower configuration, instrumentation, and specifications for the initial pilot test and extended pilot test units are shown on Figure 2.7. Following the field mobilization, Parsons ES provided a bioventing system operations and maintenance (O&M) briefing checklist and blower maintenance manual to Ft. Carson personnel. A copy of the checklist is provided in Appendix B.

The air lines connecting the blower system to each VW consists of 2-inch diameter, Schedule 40 PVC within the gravel-covered area and 2-inch diameter galvanized steel pipe within the concrete area (Figure 2.1). The PVC pipe in the gravel-covered area was buried a minimum of 18 inches beneath the ground surface and bedded with native soil. Prior to excavating the pipe trenches, the existing concrete pavement was cut and removed. The steel pipe in the concrete-covered area was buried approximately 24 inches below the concrete surface and bedded in 3/8-inch pea gravel. After placing the steel pipe and backfill, the trench was patched with a minimum 12 inches of high-early-strength concrete. The concrete was reinforced with one parallel #4 reinforcing rod along the length of the trench, with cross ties spaced approximately every 2 feet. The concrete was tied into the existing concrete pavement using #4 dowels drilled into the existing concrete and tied to the #4 reinforcing bars running parallel to the trench.

The 2-horsepower blower system has sufficient reserve air-flow capacity to provide air to future, additional VWs. The blower has an air flow capacity of approximately 110 scfm at a pressure of 40 inches of water. The excess air flow is presently being bled off using a manual gate valve (Figure 2.7).

3.0 PILOT TEST RESULTS

3.1 Soil and Soil Gas Sampling Results

Soils at this site generally consist of approximately 30 feet of dense, brittle silt and clay soils overlying siltstone bedrock. In the vicinity of VW1, MPA, MPB, and MPC, groundwater is encountered at a depth of approximately 18 feet bgs. Groundwater was measured in VW2 at a depth of approximately 19.2 feet bgs following VW construction. Based on lithological observations made at VW2 and each MP, groundwater at the site appears to be perched in the more permeable soil intervals. At MPD, MPE, and MPF perched groundwater is present at a depth of approximately 16 to 17 feet bgs, and the saturated perched zone is approximately 1 foot thick. The groundwater surface becomes deeper in the direction of MPG. Saturated soil was

LEGEND

- (1) INLET AIR FILTER - SOLBERG F-30P-150
- (2) VACUUM GAUGE (IN H₂O)
- (3) BLOWER - GAST® 2.0HP R5125Q-50
- (4) MANUAL PRESSURE RELIEF (BLEED) VALVE
1 1/2" GATE
- (5) AUTOMATIC PRESSURE RELIEF VALVE
- (6) TEMPERATURE GAUGE - (F)
- (7) PRESSURE GAUGE - (IN H₂O)
- (8) FLOW CONTROL VALVE - 1 1/2" GATE
- (9) FLOW MEASURING PORT FITTED WITH PLUG
- (10) STARTER
- (11) BREAKER BOX - 220V/SINGLE PHASE/30 AMP

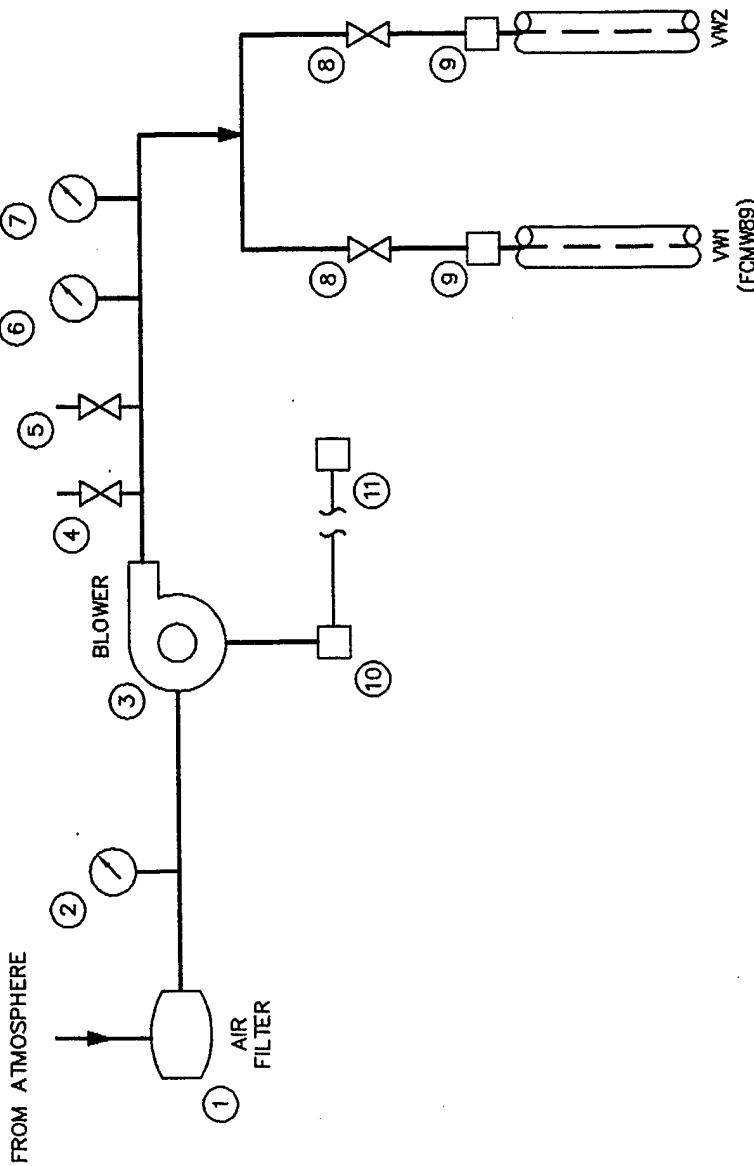


FIGURE 2.7
AS-BUILT BLOWER SYSTEM
INSTRUMENTATION
DIAGRAM FOR AIR INJECTION

Building 8200
Fort Carson, Colorado

Denver, Colorado

**PARSONS
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observed at a depth of approximately 19 feet bgs at MPG. More detailed geological information regarding Building 8200 can be found in the hydrogeologic cross-section (Figure 2.2) and the geologic boring logs (Appendix A).

Petroleum-hydrocarbon-contaminated soils at this site were encountered at depths corresponding to the perched groundwater at the VW2 and MP boreholes. Contaminated soils were identified based on odor, staining, and headspace volatile organic compound (VOC) field screening results. Contaminated soils were encountered in VW2 and all MP boreholes, with the highest contaminant concentrations occurring in the VW2 and MPE boreholes. Soils at these locations had a mild to strong hydrocarbon odor, and a petroleum-stained soil layer was encountered at depths between approximately 14 and 20 feet bgs in the two boreholes.

Soil samples for laboratory analysis were collected from Geoprobe[®] polybutyrate liners or split-spoon samplers. Soil sample headspace was screened for VOCs using a photoionization detector (PID) to determine the presence of contamination and to select soil samples for laboratory analysis. Soil samples for laboratory analysis were collected from depths of 16 to 21 feet bgs from the VW2, MPB, MPC, MPD, MPE, and MPF boreholes. A background soil sample was collected using the Geoprobe rig from an apparently uncontaminated area adjacent to monitoring well 8200-MW5 at a depth of 11 feet bgs.

Soil samples were shipped via Federal Express[®] to Inchcape Testing Services, Inc. in Richardson, Texas for chemical and physical analysis. Soil samples were analyzed for total extractable petroleum hydrocarbons (TEPH) and total volatile petroleum hydrocarbons (TVPH) by US Environmental Protection Agency (EPA) Method 8015 (modified); and for benzene, toluene, ethylbenzene, and xylenes (BTEX) by EPA Method 8020. Three samples also were analyzed for iron, alkalinity, total Kjeldahl nitrogen (TKN), and several physical parameters. The background soil sample was analyzed for TKN only. Copies of the chain-of-custody forms are included in Appendix A. The results of these analyses are provided in Table 3.1.

Six soil gas samples for laboratory analyses were collected prior to performing the *in situ* respiration test in laboratory-provided, evacuated, 1-liter SUMMA[®] canisters. Soil gas samples were collected by extracting soil gas from monitoring wells FCMW89 (VW1) and 8200-MW3; VW2; at depths of 10 and 18 feet from MPD; and at a depth of 12 feet from MPF. All soil gas samples were collected following procedures outlined in the AFCEE bioventing protocol document (Hinchee *et al.*, 1992). Soil gas samples were shipped via Federal Express[®] to Air Toxics, Inc. in Folsom, California for total volatile hydrocarbon (TVH) and BTEX analysis by EPA Method TO-3. The results of these analyses are provided in Table 3.1.

3.2 Exceptions to Test Protocol Document Procedures and Work Plan

Procedures described in the protocol document (Hinchee *et al.*, 1992) generally were followed to complete the pilot test at Building 8200. Because the soil permeability varies across the site, three abbreviated permeability tests were performed at the site: one each at FCMW88, FCMW89 (VW1), and VW2. Initial soil gas sampling performed at existing monitoring wells prior to system installation indicated

TABLE 3.1
SOIL AND SOIL GAS ANALYTICAL RESULTS
Building 8200
Fort Carson, Colorado

Analyte (Units) ^{a/}	Sample Location-Depth (feet below ground surface)				
	YW1-10-25	YV2-4-19	MPD-10	MPD-18	MPF-12
Soil Gas Hydrocarbons					MW3-4-14
TVH ^{b/} (ppmv)	21,000	24,000	42	37,000	48,000
Benzene (ppmv)	85	94	0.026	48	56
Toluene (ppmv)	13	20	0.018	24	26
Ethylbenzene (ppmv)	7.8	4.3	0.013	3.7	7.8
Xylenes (ppmv)	16	15	0.19	5.6M	5.0
Soil Hydrocarbons					MPF-17
TVPH ^{d/} (mg/kg)	486	40.1	0.267	0.795	353
TEPH ^{e/} (mg/kg)	865	272	<13.9 ^{f/}	<11.6	857
Benzene (μ g/kg)	58	<31	4.2	1.3	380
Toluene (μ g/kg)	114	<62	2.1J ^{g/}	<2.3	<580
Ethylbenzene (μ g/kg)	365	46J	<2.8	<2.3	<370J
Xylenes (μ g/kg)	16,600	409	2.5J	1.8J	13,100
Soil Inorganics					BG-11
pH (pH units)	8.0	7.6	7.6	7.6	7.6
Iron (mg/kg)	31,900	23,000	28,100	28,100	28,100
Alkalinity (mg/kg as CaCO ₃)	177	70.3	148	148	148
TKN (mg/kg)	314	1,200	711	711	711
Phosphates (mg/kg)	55.3	51.3	46.3	46.3	46.3
Soil Physical Parameters					MPF-16
MPA-20		MPD-9	MPF-15	MPF-12	MPF-12
Moisture (% wt.)	15.4	14.7	15.3	15.3	15.3
Gravel (%)	0.0	0.0	0.0	0.0	0.0
Sand (%)	2.3	11.1	13.3	13.3	13.3
Silt (%)	67.7	55.8	54.5	54.5	54.5
Clay (%)	30.0	33.2	32.3	32.3	32.3
Temperature (°F)	---	---	---	56.1	53.1

^{a/} mg/kg=milligrams per kilogram; ppmv=parts per million, volume per volume; TKN=total Kjedahl nitrogen; TVH=total volatile hydrocarbons; TVPH=total volatile petroleum hydrocarbons; TEPH=total extractable petroleum hydrocarbons; CaCO₃ = calcium carbonate; wt.=weight; °F = degrees Fahrenheit.

^{b/} TVH referenced as jet fuel (MW=156) and analyzed by USEPA Method TO-3.

^{c/} M = Laboratory reported value may be biased due to apparent matrix interferences.

^{d/} TVPH referenced as gasoline and analyzed for by USEPA Method SW8015 modified.

^{e/} TEPEH referenced as diesel and analyzed for by USEPA Method SW8015 modified.

^{f/} < indicates that the analyte was not detected; the number provided is the method detection limit.

^{g/} Benzene, toluene, ethylbenzene, and total xylenes analyzed by EPA Method SW8020.

^{h/} J = Indicates a laboratory estimated value. This flag is used if the compound is detected but is below the reporting limit.

^{i/} --- = Not analyzed.

that the soils north of the former tanks may be less permeable than the soils southeast of the tanks. Because no pressure response was observed during each of the tests, the test durations were shortened (4 to 8 hours is recommended). Further explanation of the permeability tests is provided in Section 3.4.

A total of seven MPs and one VW were installed at the site, rather than the five MPs and two VWs proposed in the work plan (Parsons ES, 1996). Difficulty in obtaining soil gas samples from MPB-15.5, MPB-20, MPC-15, MPC-23, MPE-11, MPF-16, and MPG-22 necessitated placement of additional MPs. MPD, MPE, and MPF were installed with an auger drill rig rather than the Geoprobe[®] rig.

3.3 Initial Soil Gas Chemistry

Prior to initiating any air injection, soil gas in the two VWs, all MPs, and each of the existing onsite groundwater monitoring wells was analyzed for initial oxygen, carbon dioxide, and TVH concentrations using portable gas analyzers, as described in the technical protocol document (Hinchee *et al.*, 1992). Table 3.2 summarizes the initial soil gas chemistry. The VWs, MPs, and MWs were purged until oxygen levels had stabilized to remove stagnant gas prior to collecting soil gas samples.

At the VWs, FCMW88, 8200-MW1, 8200-MW2, 8200-MW3, and all MP screened intervals from which soil gas samples could be collected (except MPA), soil gas oxygen concentrations were below the atmospheric concentration of approximately 21 percent. Depleted oxygen concentrations indicate significant biological activity and soil contamination. The most significant oxygen depletion was measured at VW1, VW2, MPD-18, MPF-12, MPG-13, 8200-MW1, and 8200-MW2, where the oxygen concentrations were at or below 5 percent. Soil and soil gas results strongly indicate significant soil contamination at VW2. An oxygen concentration of 1.5 percent at this location corresponds with a total BTEX concentrations of 17,137 micrograms per kilogram ($\mu\text{g}/\text{kg}$), in the soil sample from the 16 foot depth (Table 3.1). These results clearly indicate significant biological activity associated with contaminated soils. Initial oxygen concentrations at MPA-16, MPA-19, MPE-7, FCMW88, 8200-MW4, and 8200-MW5 ranged from 6.8 to 20.8 percent. These higher soil gas oxygen concentrations coupled with lower soil gas TVH concentrations (Table 3.2) indicate less fuel contamination (and resulting biological activity) at these locations.

TVH field measurements at the VWs and MPs ranged from 46 to greater than 20,000 parts per million, volume per volume (ppmv), and laboratory TVH results ranged from 42 to 48,000 ppmv. The highest TVH concentrations in MPs were measured at depths below 12 feet, indicating significant fuel contamination.

3.4 Air Permeability/Oxygen Influence

The depth and radius of oxygen increase in the subsurface resulting from air injection into the VW during pilot testing is the primary design parameter for expanded-scale bioventing system design. Optimization of expanded-scale and multiple VW systems require pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

TABLE 3.2
INITIAL SOIL GAS CHEMISTRY
BUILDING 8200
FORT CARSON, COLORADO

Sample Location	Screen Depth (feet)	O ₂ (%)	CO ₂ (%)	Field TVH (ppmv) ^{a/}	Laboratory TVH (ppmv) ^{b/}
FCMW89(VW1)	9.5-24.5	3.0	7.4	6,200	21,000
8200-VW2	4.5-19.5	1.5	14.0	14,000	24,000
8200-MPA	16.0	20.8	0.05	0	--- ^{c/}
8200-MPA	19.0	20.8	0.05	2,000	---
8200-MPB ^{d/}	15.5	---	---	---	---
8200-MPB ^{d/}	20.0	---	---	---	---
8200-MPC ^{d/}	15.0	---	---	---	---
8200-MPC ^{d/}	23.0	---	---	---	---
8200-MPD	10.0	0.8	6.8	300	42
8200-MPD	18.0	0.9	5.3	>20,000	37,000
8200-MPE	7.0	6.8	5.2	46	---
8200-MPE	11.0	18.2	0.1	95	---
8200-MPF	12.0	0.0	6.6	20,000	48,000
8200-MPF ^{e/}	16.0	---	---	---	---
8200-MPG	13.0	5.0	5.8	78	---
8200-MPG ^{d/}	22.0	---	---	---	---
8200-MW1	5.8-15.8	4.1	3.8	2,200	---
8200-MW2	7.6-17.6	0.7	6.5	10,200	---
8200-MW3	4.1-14.1	0.0	9.1	200	80
8200-MW4	6.8-16.8	20.5	0.5	250	---
8200-MW5	12.1-22.1	19.8	1.4	260	---
FCMW88	14.5-29.5	8.4	4.0	65	---

^{a/} Total volatile hydrocarbon field screening results reported in parts per million, volume per volume.

^{b/} Laboratory total volatile hydrocarbon analytical results by EPA Method TO-3 referenced to jet fuel (molecular weight=156).

^{c/} --- = Not analyzed.

^{d/} Unable to obtain a soil gas sample due to impermeable soil conditions.

^{e/} Monitoring point screened interval was within perched groundwater.

Abbreviated air permeability tests were conducted at each of wells FCMW88, FCMW89 (VW1), and VW2. A 1-hour permeability test was performed at well FCMW88 to determine the feasibility of utilizing the well for air injection during future expanded-scale system installation. Air was injected into FCMW88 for 1 hour at a rate of approximately 17.5 scfm and an average pressure of 50 inches of water. No pressure response was measured at MPF-12, MPE-7, and VW2. Following the first hour of air injection, the injection rate was increased to 18.5 scfm at a pressure of 62 inches of water. Again, no pressure response was measured at any of the monitoring locations. Following the permeability test at FCMW88, oxygen influence was measured at MPF-12, MPE-7, MPD-10, and MPD-18. Results indicated a 1 percent (%) increase in oxygen concentration at MPF-12 only. Based on the negligible pressure response observed from injecting at FCMW88, and the high blower pressure that was required, a new VW should be installed near FCMW88 during expanded-scale system installation.

Following oxygen influence measurements, air was injected into VW2 for 1.5 hours at a rate of approximately 19.5 scfm and an average pressure of 44 inches of water. No pressure response was measured at MPD-10, MPD-18, MPE-7, MPE-11, MPF-12, MPG-13, and FCMW88. After 1.5 hours of air injection, the air injection flow rate was increased to 22 scfm at a pressure of 58 inches of water. Again, no pressure response was observed at any of the MPs after an additional hour of air injection, therefore the permeability test was terminated. Following the permeability test at VW2 (after 2.5 hours of air injection), oxygen influence was measured at MPG-13, MPF-12, MPE-7, MPD-10, and MPD-18. Results indicated an oxygen concentration increase of 0.5% at MPG-13, 13.1% at MPF-12, 2.4% at MPE-7, 4.5% at MPD-10, and 0.0% at MPD-18.

Pressure response measurements were also collected following 46 hours of air injection at FCMW89 (VW1) and VW2. Again, no pressure response was observed at any of the MPs. At air injection flow rates of approximately 13.5 scfm at VW1 (FCMW89) and 15.3 scfm at VW2, and a blower pressure of 25 inches of water, no pressure response was observed at MPA (located 10 feet from VW1) or at any of the other MPs at the site. Due to the negligible pressure response at the site, an estimated soil gas permeability value could not be calculated. Pressure response measurements will be collected again prior to expanded-scale system installation activities

Because the permeability tests did not provide information that was useful in determining the expected radius of oxygen influence, changes in soil gas oxygen levels were measured following a 46-hour injection period using the extended pilot test blower unit and VW-2. Results of this oxygen influence testing are presented in Table 3.3. This period of air injection produced increases in soil gas oxygen levels at all MPs (where a soil gas sample was obtainable) and monitored wells except 8200-MW1. Based on measured changes in oxygen levels, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 31 feet at depths corresponding to the more permeable sand lenses. Within the less permeable fine grained soils, oxygen will likely diffuse from the permeable zones into the less permeable soils.

TABLE 3.3
INFLUENCE OF AIR INJECTION AT VW2 ON
MONITORING POINT OXYGEN CONCENTRATIONS
BUILDING 8200
FORT CARSON, COLORADO

Location	Distance From VW2 (feet)	Screen Depth (feet bgs) ^{a/}	Initial O ₂ (%)	Final O ₂ ^{b/} (%)	Initial TVH (ppmv) ^{c/}	Final TVH (ppmv) ^{c/}
MPD	14.6	10.0	13.5 ^{d/}	19.1	---	---
MPD	14.6	18.0	9.1 ^{d/}	14.4	3,000	2,100
MPE	18.1	7.0	6.0 ^{e/}	8.9	0	0
MPF	31.1	12.0	0.0 ^{f/}	0.3	20,000	>20,000
MPG	30.5	13.0	17.5 ^{d/}	17.7	34	33
8200-MW1	96.0	5.8-15.8	4.1 ^{g/}	1.2	2,200	4,000
8200-MW2	114.7	7.6-17.6	0.7 ^{g/}	0.9	10,200	12,800
8200-MW3	149.0	4.1-14.1	0.3 ^{g/}	0.3	240	500

^{a/} bgs = below ground surface.

^{b/} Measurements taken after approximately 46 hours of air injection at VW2.

^{c/} Field measurement for total volatile hydrocarbons (TVH) in parts per million, volume per volume.

^{d/} Measurement taken following respiration testing and air injection at FCMW88, and prior to air injection at VW2.

^{e/} --- = Not sampled.

^{f/} Measurement taken following air injection at FCMW88 and prior to air injection at VW2.

^{g/} Measurement taken prior to air injection at FCMW88 and VW2.

A radius of oxygen influence (RI) of at least 31 feet was observed at screened depths greater than 6 feet within the concrete-covered area. At 8200-MW2, located 115 feet from VW2 (Figure 2.1), the oxygen concentration increased from 0.7 to 0.9 percent following 46 hours of air injection. The observed oxygen increase may be attributable to inherent sampling inconsistencies; however, the TVH concentrations also increased, signifying that 8200-MW2 may actually be within the VW2 oxygen RI. In addition, soil gas monitored at 8200-MW1, which is located 96 feet from VW2, showed a decrease in oxygen concentrations, indicating that the soil gas was migrating outward from the area of higher contamination near VW2 into the area of lesser contamination near 8200-MW1. The expected RI at VW1 is likely less than that of VW2. Monitoring wells FCMW88 and FCMW89 (VW1) seem to have been constructed in a manner such that the permeability of the screened zone is less than that observed at the other site monitoring wells and at VW2. Because an oxygen-depleted MP at which soil gas was obtainable is not available near VW1, a MP should be installed near VW1 during expanded-scale system installation to determine the actual RI of VW1. Soil gas monitoring will be conducted prior to the expanded-scale system installation to better define the effective treatment radius.

3.5 *In Situ* Respiration Rates

The *in situ* respiration test was performed by injecting a mixture of air (oxygen) and approximately 10-percent helium (inert tracer gas) into VW2 and two MP screened intervals (MPD-10, and MPD-18) and injecting ambient air into MPG-13 for a 16-hour period. Oxygen loss and other changes in soil gas composition over time were then measured at these intervals. Oxygen, TVH, carbon dioxide, and helium were measured for a period of approximately 11 days following air injection. The measured oxygen losses were then used to calculate biological oxygen utilization rates. The results of *in situ* respiration testing for VW2, MPD-10, MPD-18, and MPG-13 are presented in Figures 3.1 through 3.4, respectively. Table 3.4 provides a summary of the oxygen utilization and fuel degradation rates.

Because helium is a conservative, inert gas, the change in helium concentrations over time can be useful in determining the effectiveness of the bentonite seals between MP screened intervals. Figures 3.1 through 3.3 compare oxygen utilization and helium retention. Because the observed helium losses were negligible, and because helium will diffuse approximately three times faster than oxygen due to oxygen's greater molecular weight, the measured oxygen loss can be inferred to be the result of bacterial respiration and not due to diffusion away from the MPs. Throughout the testing, helium concentrations increased, possibly due to varying helium injection flow rates.

Oxygen loss measured at VW2, MPD-10, MPD-18, and MPG-13 occurred at slow rates, ranging from 0.01 percent per hour at MPG-13 to 0.06 percent per hour at VW2. At VW2, the oxygen dropped from 20.8 percent to 14.0 percent in 10 days (14,580 minutes).

Based on these oxygen utilization rates, an estimated 20 to 80 mg of fuel per kg of soil can be degraded each year at this site. This conservative estimate is based on an average air-filled porosity of approximately 0.045 liter per kg of soil, and a ratio of 3.5

FIGURE 3.1
INITIAL RESPIRATION TEST RESULTS AT VW2
BUILDING 8200
FORT CARSON, COLORADO

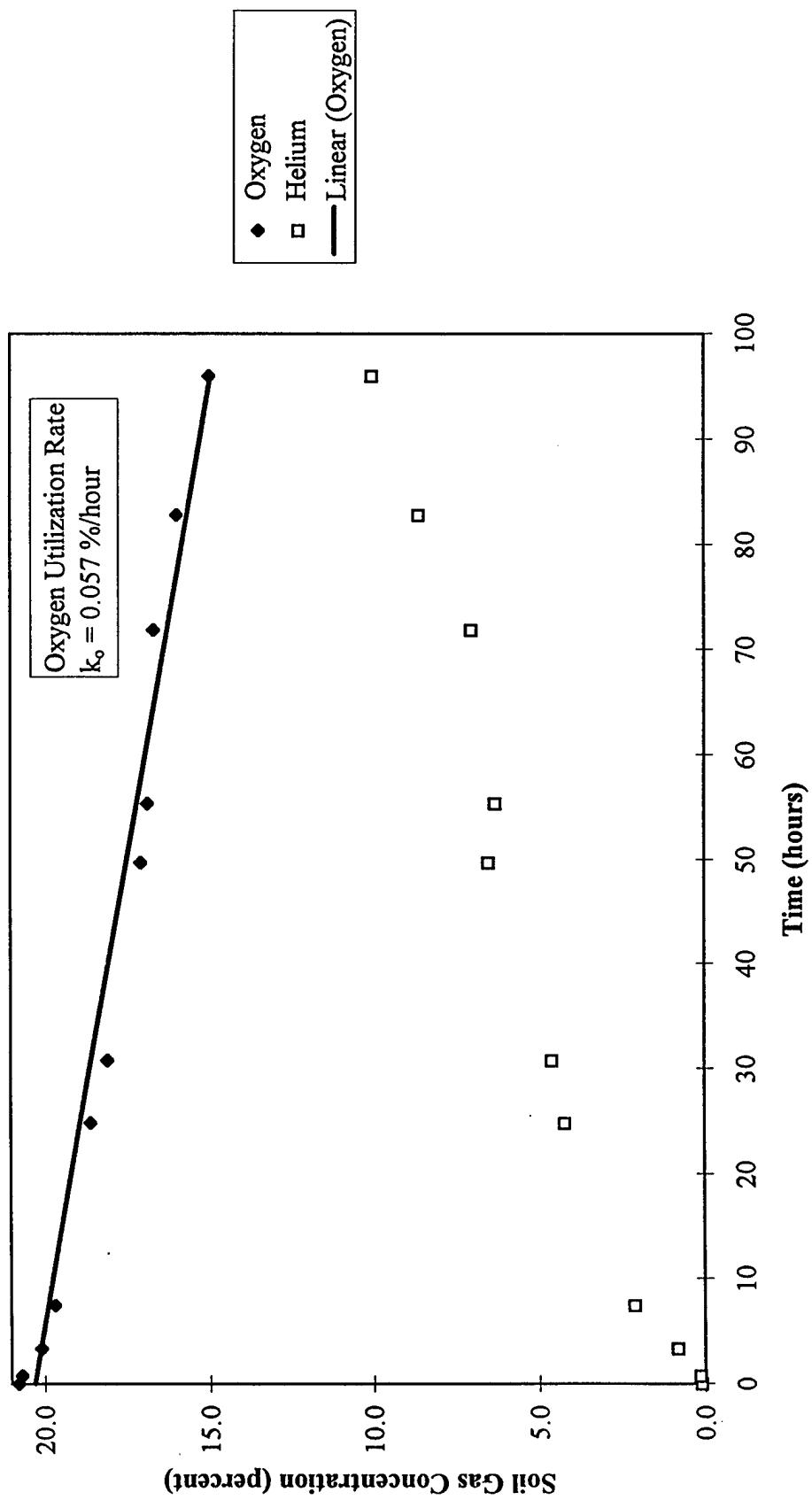


FIGURE 3.2
INITIAL RESPIRATION TEST RESULTS AT MPD-10
BUILDING 8200
FORT CARSON, COLORADO

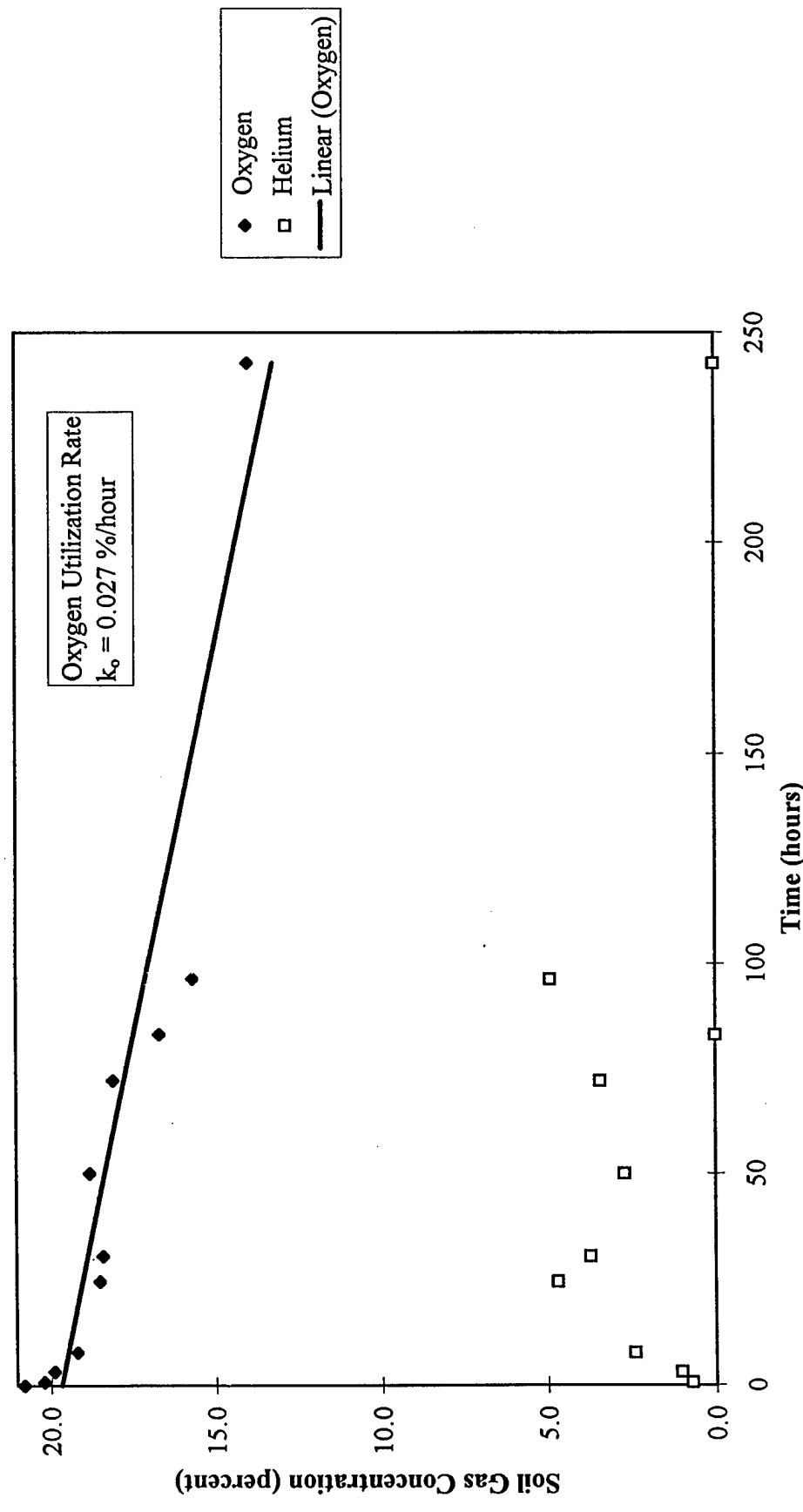


FIGURE 3.3
INITIAL RESPIRATION TEST RESULTS AT MPD-18
BUILDING 8200
FORT CARSON, COLORADO

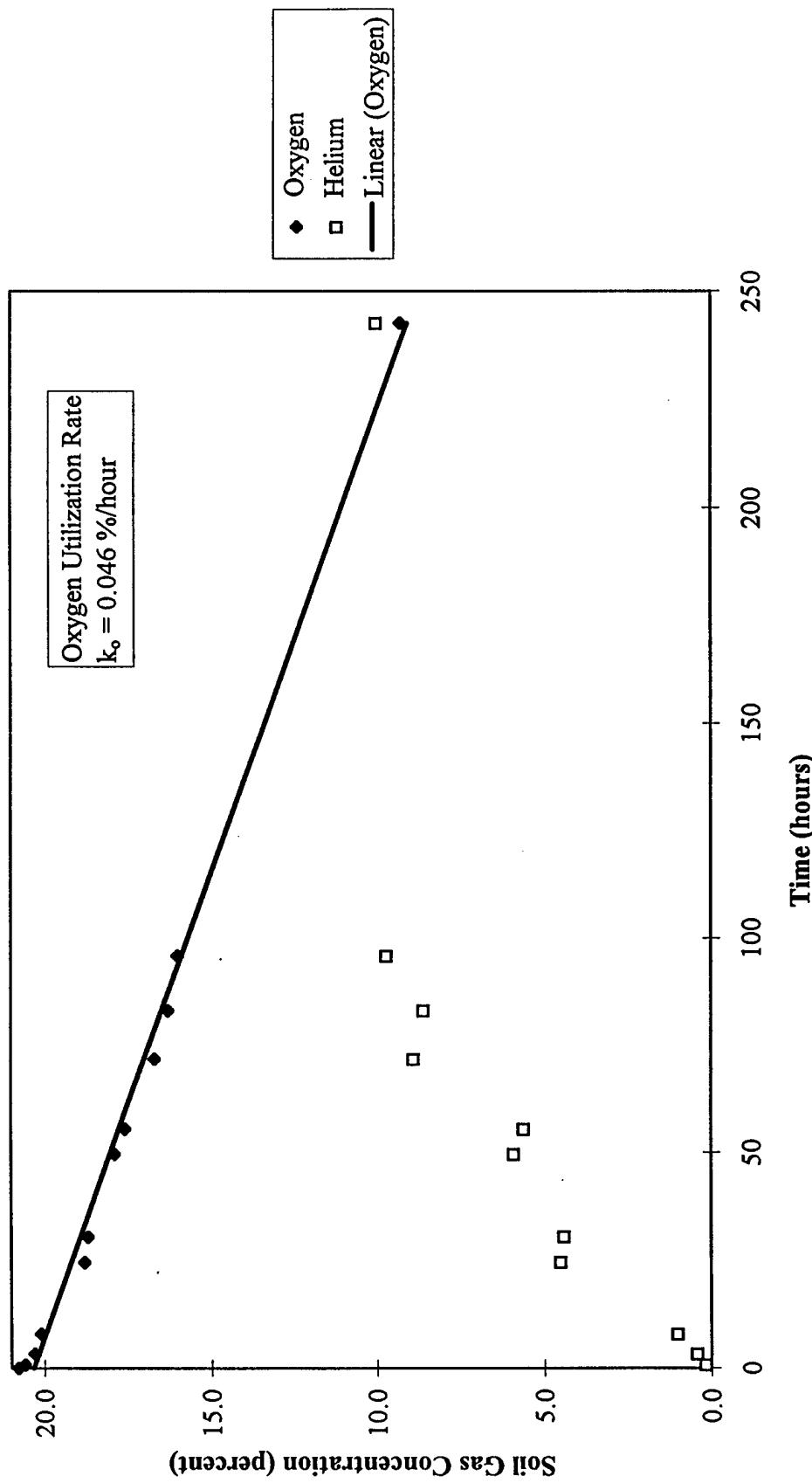


FIGURE 3.4
INITIAL RESPIRATION TEST RESULTS AT MPG-13
BUILDING 8200
FORT CARSON, COLORADO

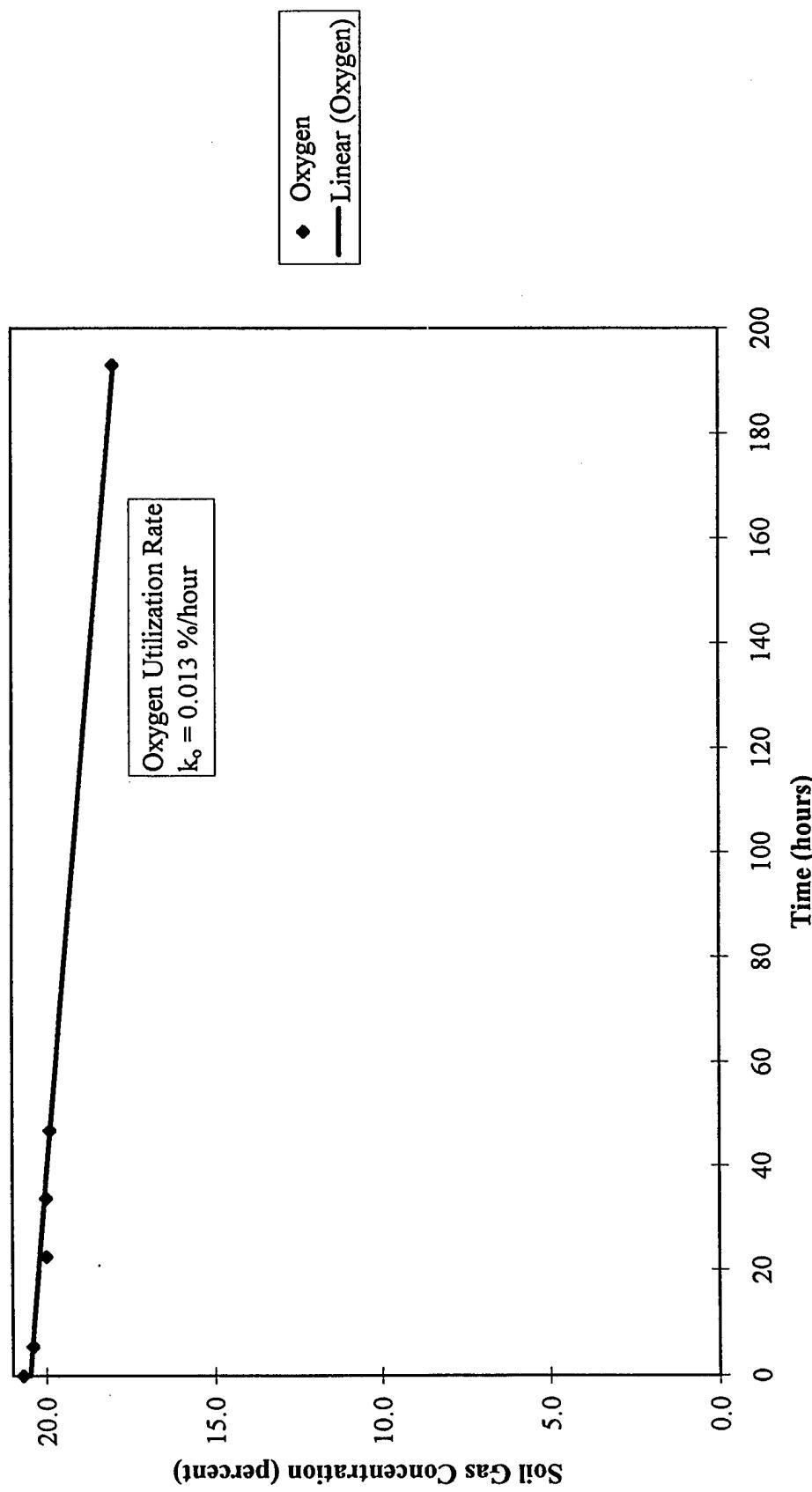


TABLE 3.4
OXYGEN UTILIZATION AND FUEL DEGRADATION RATES
BUILDING 8200
FORT CARSON, COLORADO

Location- Depth (feet bgs)^{a/}	Test Duration (hours)	O₂ Loss (%)	O₂ Utilization Rate^{b/} (%/hour)	Fuel Degradation Rate (mg TPH/kg/year)^{c/}
VW2 4.5-19.5	96	5.8	0.056	84
MPD-10	243	6.8	0.027	40
MPD-18	243	11.5	0.046	70
MPG-13	193	2.7	0.013	20

^{a/} bgs = below ground surface.

^{b/} Values based on best-fit lines (Figures 3.1 through 3.4).

^{c/} mg TPH/kg/year = milligrams of total petroleum hydrocarbons degraded per kilogram of soil per year.

mg of oxygen consumed for every 1 mg of fuel biodegraded. Actual degradation rates may vary from these estimates.

3.6 Potential Air Emissions

The long-term potential for VOC air emissions from expanded-scale bioventing operations at this site is considered low because of the age and type of the site contaminants (greater than 5 years, and primarily diesel fuel); the very low air injection flow rates (13 scfm); and the concrete cover. Air emissions should be minimal because accumulated vapors will move slowly outward from the air injection points and will be biodegraded as they move horizontally through the soil.

Air emissions monitoring was conducted during pilot-scale system startup at four locations (Figure 2.1) using a GasTech total volatile hydrocarbon analyzer sensitive to 1 ppmv volatile hydrocarbons. Table 3.5 presents the results of both the initial and 2-hour readings. Because the potential for air emissions is highest during the initial hours of injection, and because no TVH emissions were detected, the long-term emission potential is considered low.

4.0 RECOMMENDATIONS

Initial bioventing tests at this site indicate that oxygen has been depleted in the contaminated soils, and that air injection is an effective method of increasing aerobic fuel biodegradation. A small, 2-horsepower regenerative blower has been installed at the site to continue air injection at a rate of approximately 13 scfm at each of the two VWs. It is recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing temperatures on fuel biodegradation rates. Although biodegradation rates are slow at the Building 8200 site, Parsons ES recommends that expanded-scale bioventing be retained as the presumptive remedy for remediation of the vadose zone soils. As contracted under an Option 4 on the AFCEE Extended Bioventing Project, Parsons ES will prepare a Remedial Action Plan for Vadose Zone Soils and expanded-scale bioventing design package that will be delivered in early 1997. It is anticipated that expanded-scale system installation activities may begin as early as February 1997.

After one year of expanded-scale system operation, Parsons ES will collect soil gas samples from several monitoring points that were sampled during the initial sampling event and during the future expanded-scale system installation to determine the levels of cleanup achieved after approximately 1 year of *in situ* treatment.

The pilot-scale bioventing system is treating only a portion of the full-areal extent (FAE) of vadose zone contamination. Based on the results of previous site investigations, several more VWs will be required to treat the FAE of petroleum contamination. Figure 4.1 shows the recommended VW and MP locations for expanded-scale bioventing system installation in the areas of known contamination. Results of additional site characterization work to be performed by Foothills Engineering Consultants will better define the FAE of contamination. It is recommended that expanded-scale system installation activities be coordinated with the site characterization field work. Site characterization soil borings may be converted for

TABLE 3.5
AIR EMISSIONS MONITORING RESULTS
BUILDING 8200
FORT CARSON, COLORADO

Emission Monitoring Location	Initial TVH (ppmv)^{a/}	Final TVH (ppmv)^{b/}
1	0	0
2	0	0
3	0	0
4	0	0

^{a/} TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume.

^{b/} Final TVH readings were collected 2 hours after blower start up.

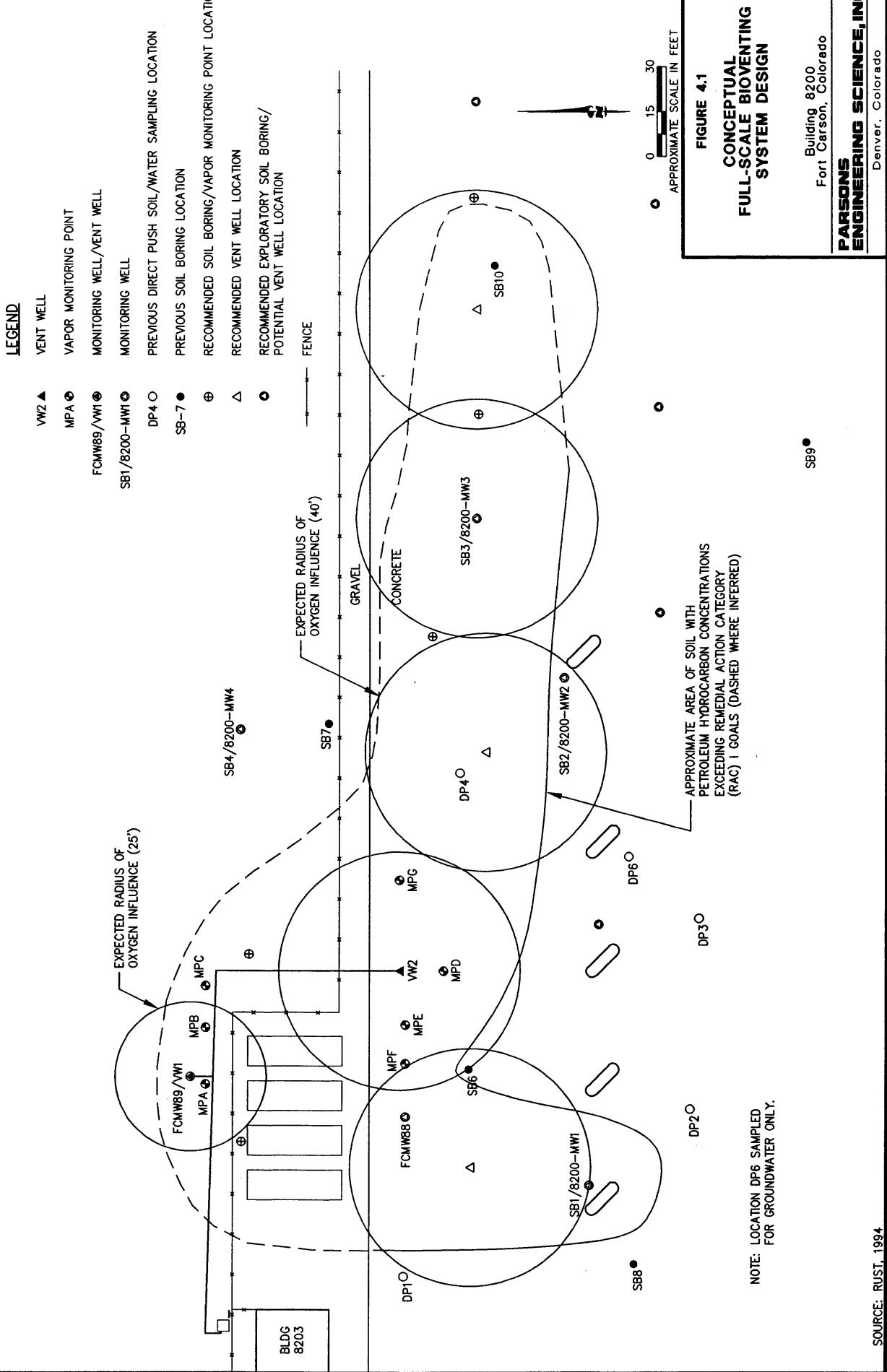


FIGURE 4.1

**CONCEPTUAL
FULL-SCALE BIOVENTING
SYSTEM DESIGN**

use as VWs or MPs. VWs should be constructed in the same manner as VW2, and MPs should be constructed with the soil gas screens installed within 3-foot-thick sand pack intervals. Difficulty in obtaining soil gas samples from the recently installed MPs indicates that a thicker screened interval is necessary to ensure that each MP functions properly.

The current 2-horsepower blower system has sufficient capacity to provide air flow to about 5 additional VWs. Based on available site data, at least four additional VWs will be required at the Building 8200 site. Review of the construction details of the existing monitoring wells (Appendix A) indicates that 8200-MW3, which is located within the area of contamination is suitable for use as a VW. Also, monitoring wells 8200-MW1 and 8200-MW2 are suitable for use as vapor MPs. Therefore, it is recommended that at least four new VWs (including 8200-MW3) and five new MPs be installed at the site during expanded-scale system installation.

5.0 REFERENCES

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APPENDIX A
GEOLOGIC BORING LOGS,
CHAIN-OF-CUSTODY FORMS,
TEST DATA, AND CALCULATIONS

GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73300
 BORING NUMBER: 8200-VW2
 RIG TYPE: CME 75
 TEMPERATURE (°F): ~75°F

CLIENT: AFCEE/AEC/Ft. Carson
 BORING DIA.: 11-inch
 CONTRACTOR: Ground Exploration
 WEATHER: Clear & breezy from NE
 DRLG MED: HSA

DATE: 7/23/86
 ELEVATION:
 DATUM:
 GEOLOGIST: D. Teets

COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Time /		Remarks
					Laboratory Sample Identification	Sample Type	
1							Dark brown intervals may = petroleum staining
2							
3							
4			4-5.5': Stiff Clay, silty, brittle, brn / dark brn intervals, sm calcite present, iron oxide staining, dry, no odor or stain	1445	ss	65.5' 9.7' 2.4'	Recovery = 18/24 Blows: 6, 15, 20, 28
5							
6			6-7.5': SAA	1455	ss	27.5' 10.0' 2.4'	Recovery = 18/24 Blows: 10, 18, 28, 39
7							
8			8-10': SAA except SI moist	1515	ss	29.5' 9.2' 2.4'	Recovery = 18/24 RH = 13.9 / 3.2 BZ = 3.2 / 3.2
9							
10			10-12': SAA except moist, more calcite content	1525	ss	21.0' 9.2' 2.4'	Recovery = 21/24 Blows: 14, 29, 43, 59
11							
12			12-14': SAA	1535	ss	21.2' 9.2' 2.4'	Recovery = 24/24 Blows: 7, 13, 19, 28
13							
14			14-16': SAA except fuel odor starting at about 15'	1545	ss	21.4' 9.7.1' 2.6'	Recovery = 24/24 RH = 16.4 / 2.9 BZ = 2.9 / 2.9
15							
16			16-18': SAA except wet	1555	ss	21.6' 3.54' 2.6'	Recovery = 24/24 Blows: 9, 13, 21, 24
17			GWS about 16' bgs				
18							
19			TD = 19.5' bgs				
20							

PID - Photoionization Detector

bgs - Below Ground Surface

G - Grab Sample

BH - Borehole

na - Not Analyzed

SAA - Same As Above

ppmv - Parts per Million, Volume per Volume

Bkgrnd - Background

HS - Sample Headspace

HSA - Hollow Stem Auger

SS - Split Spoon Sample

ft - Feet

BS - Brass Sleeve Sample

GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330
 BORING NUMBER: 8200-MPA
 RIG TYPE: Geoprobe
 TEMPERATURE (°F): 75

CLIENT: AFCEE/AEC/Ft. Carson
 BORING DIA.: 2-inch
 CONTRACTOR: Parsons Engineering Science
 WEATHER: Sunny
 DRLG MED: Direct Push

DATE: 7/16/96
 ELEVATION:
 DATUM:
 GEOLOGIST: D. Teets

COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1			14-16': Clay, sm silt, dark brn/lt brown wsm maroon, moist, no odor or staining					Sample / Rgnd time 922
2								
3								
4								
5		6-8' gash	46': Clay, tr sand lenses, dark brn/ lt brn w/white, dry, no odor or staining.					749 Actually 6-8' gash
6								
7								
8								
9								
10			10-12': Clay, tr sand f lenses, dark brn/lt brn w/white, dry, no odor or staining.					time 825
11								
12								
13								
14		12-14'	14-16': Clay, sm sand f lenses, dark brn/lt brn, w/white, dry to moist, no odor or staining					16.1 3.2 ③ 14' 12.4
15								
16								
17			16-18': Clay, sm silt, dark brown/lt brown w/white, moist, dense, no odor or staining					17.3 3.2 14 ② 16.9 13.4 3.2 C15 11.2 2.1 ③ 18.6
18								
19								
20								

PID - Photoionization Detector

bgs - Below Ground Surface

G - Grab Sample

BH - Borehole

na - Not Analyzed

SAA - Same As Above

ppmv - Parts per Million, Volume per Volume

Bkgrnd - Background

HS - Sample Headspace

HSA - Hollow Stem Auger

SS - Split Spoon Sample

ft - Feet

BS - Brass Sleeve Sample

GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 07/16/96
 BORING NUMBER: 8200-MPA BORING DIA.: 2-inch ELEVATION:
 RIG TYPE: Geoprobe CONTRACTOR: Parsons ES DATUM:
 TEMPERATURE (°F): 75 WEATHER: sunny GEOLOGIST: D. Teets
 DRLG MED: direct push

COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
21			20-22': Clay, sm silt, dk brn/t brn, dense ✓ moist 20-21' odor, 21-22' odor and staining recovery 24/24"	X	8200-MPA-20 Physical properties 8200-MPA-21 TPH, TEPH, BTEX		107 2.4	time 10:55
22								②22'
23								
24								
25								
26								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

PID - Photoionization Detector

bgs - Below Ground Surface

G - Grab Sample

BH - Borehole

na - Not Analyzed

SAA - Same As Above

ppmv - Parts per Million, Volume per Volume

Bkgrnd - Background

HS - Sample Headspace

HSA - Hollow Stem Auger

SS - Split Spoon Sample

ft - Feet

BS - Brass Sleeve Sample

GEOLOGIC BORING LOG

JOB NUMBER.:	726876.73330	CLIENT:	AFCEE/AEC/Ft. Carson	DATE:	07/16/96
BORING NUMBER:	8200-MPB	BORING DIA.:	2-inch	ELEVATION:	
RIG TYPE:	Geoprobe	CONTRACTOR:	Parsons Engineering Science	DATUM:	
TEMPERATURE (°F):	50°	WEATHER:		GEOLOGIST:	D. Teets
COMMENTS: _____					

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								Sample/bkg
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14			14-16': Clay, tr sand lenses, dk brn/lt brn moist, dense, no odor or staining				① 14 3.7 3.2	time 1500
15								
16			recovery 23/24'				② 16 15.6 3.2	time 1529
17			16-18': Clay, tr sand lenses, dk brn/lt brn, moist, dense, no odor or staining					
18			recovery 23/24"				③ 18 16.3 3.2	time 1645
19			18-20': Clay, crystalline lenses, lt brn w/white crystals, moist, dense, odor and staining					
20			recovery 23/24"				④ 22 22.9 3.1	379/2.9
		20-22' gall						

PID - Photoionization Detector

bgs - Below Ground Surface

G - Grab Sample

BH - Borehole

na - Not Analyzed

SAA - Same As Above

ppmv - Parts per Million, Volume per Volume

Bkgrnd - Background

HS - Sample Headspace,

HSA - Hollow Stem Auger

SS - Split Spoon Sample

ft - Feet

BS - Brass Sleeve Sample

GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330
 BORING NUMBER: 8200-MPC
 RIG TYPE: Geoprobe
 TEMPERATURE (°F): 75°

CLIENT: AFCEE/AEC/Ft. Carson
 BORING DIA.: 2-inch
 CONTRACTOR: Parsons Engineering Science
 WEATHER: Sunny
 DRLG MED: Direct Push

DATE: 07/17/96
 ELEVATION:
 DATUM:
 GEOLOGIST: D. Teets

COMMENTS:

Depth (ft.)	Pro- file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								Sample 10Kg
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14			14-16': Clay, tr sand lenses, dark brn / lt brn, moist, dense, no odor or staining				014 13.6 / 2.9	time 852
15								
16							016 5.2/2.6	time 936
17			16-18': Clay, crystalline lenses, tr sand lenses, dark brn / lt brn w/ white crystals, moist, no odor or staining					
18							018 10.4 / 2.6	time 1007 sample caught in tube
19			18-20': Clay, sm silt, dark brn / lt brn, moist, no odor or staining					
20							020 15.6/2.6	

PID - Photoionization Detector

bgs - Below Ground Surface

G - Grab Sample

BH - Borehole

na - Not Analyzed

SAA - Same As Above

ppmv - Parts per Million, Volume per Volume

Bkgrnd - Background

HS - Sample Headspace

HSA - Hollow Stem Auger

SS - Split Spoon Sample

ft - Feet

BS - Brass Sleeve Sample

GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330
 BORING NUMBER: 8200-MPC
 RIG TYPE: Geoprobe
 TEMPERATURE (°F): 85

CLIENT: AFCEE/AEC/Ft. Carson
 BORING DIA.: 2 inch
 CONTRACTOR: Parsons ES
 WEATHER: sunny
 DRLG MED: Direct Push

DATE: 07/17/96
 ELEVATION:
 DATUM:
 GEOLOGIST: D. Teets

COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
21			20-22': Clay, sm silt, drk brn/tbrn w/t of copper, moist, dense, no odor or staining	X	8200-MPC-21 TVPH, TEPH, BTEX			time 1050
22			22-24': Clay, sm silt, drk brn/tbrn, moist, v dense, no odor or staining	X				
23			22-24': Clay, sm silt, drk brn/tbrn, moist, v dense, no odor or staining	X				
24								
25			24-26: Clay, sm silt, drk brn, moist, v dense, no odor or staining					
26								
27								
28								
29			28-30': Clay, sm silt, sm sand, dark brn w/white silt, lt brn sand, moist & dense, no odor or staining	X				time 1701
18-30			recovery 24"/24"					refusal @ 29' 30' SAA
31								
32								
33								
14								
15								
16								
17								
18								
19								
20								

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

GEOLOGIC BORING LOG

JOB NUMBER.:	726876.73300	CLIENT:	AFCEE/AEC/Ft. Carson	DATE:	07/18/96
BORING NUMBER:	8200- MPC 2	BORING DIA.:	2-inch	ELEVATION:	
RIG TYPE:	Geoprobe	CONTRACTOR:	Parsons ES	DATUM:	
TEMPERATURE (°F):	80	WEATHER:	cloudy	GEOLOGIST:	D. Teets
DRLG MED: Direct Push					

COMMENTS: _____

Depth (ft.)	Pro- file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
			20-22': Clay, tr silt, tr gypsum crystals, dark brn, moist, v dense, no odor or staining				③ 20' ② 21-22.61 ② 21-22.62 ② 21-22.63	16.7/2.6 14.4/2.6 15.2/2.6 14.1/2.6
21								time 922
22			recovery 21/24					
3			22-24': Clay, sm gypsum leaves, dark brn/ lt brn, moist, v dense, odors and staining 22-23' odors 23-24'				③ 22' ③ 22' 283/ 283/2.6	time 1108
4			recovery 24/24					
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

GEOLOGIC BORING LOG

JOB NUMBER.:	726876.73330	CLIENT:	AFCEE/AEC/Ft. Carson	DATE:	7/23/96
BORING NUMBER:	8200-MPD	BORING DIA.:	2-inch 8-inch	ELEVATION:	
RIG TYPE:	Geoprobe SME75	CONTRACTOR:	Parsons Engineering Science (Orland, CA)	DATUM:	
TEMPERATURE (°F):	~80°F	WEATHER:		GEOLOGIST:	D. Teets
		DRLG MED:	Direct Push Solid Stem		

COMMENTS: _____

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330
 BORING NUMBER: 8200-MPE
 RIG TYPE: Geoprobe CME75
 TEMPERATURE (°F): ~75°F

CLIENT: AFCEE/AEC/Ft. Carson
 BORING DIA.: 2 inch 11-inch
 CONTRACTOR: Parsons Engineering Science (Ground Ex.)
 WEATHER: Cloudy, calm
 DRLG MED: Direct Push HSA

DATE: 7/24/96
 ELEVATION:
 DATUM:
 GEOLOGIST: D. Teets

COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								
2								
3								
4								
5			5-6.4': Clay, silty, stiff, brittle, brn / blk intervals, calcite present, iron oxide staining, dry, no odor	X	1445		0.55 9.7 2.4	Recovery = 16/24
6				X			0.6 11.3 2.4	Blows: 1, 3, 6, 13
7				X				C
8								
9								
10			10-12': SAA except more calcite content	X	1500		0.10 10.9 2.4	Recovery = 24/24
11				X			0.11 9.7 2.1	Blows: 11, 26, 33, 48
12			12-13': SAA	X	1505		0.12 11.0 2.1	BH = 2.6/2.6
13			13-14': Clay, sm silt, L+brn, tr. calcite, iron oxide staining, moist, no odor, no sm blk staining	X			0.14 74.0 2.1	BZ = 2.6/2.6
14			14-14.5': (try SAA) 10-12' interval, except moist	X	1515		0.16 27.4 2.4	Recovery = 24/24
15			14.5-16': Clay, silty, very brittle, calcite crystals very prevalent, v moist, brn w/ blk staining, sl pet. odor	X			0.17 42.9 5.0	BH = 2.7/2.9
16			16-18': SAA except less calcite & dry	X	1525		0.18 17.6 5.0	BZ = 2.9/2.9
17				X			0.20 17.8 5.0	Blows: 6, 10, 14, 18
18			18-20': SAA (16-18 except no odor)	X	1535			Recovery = 24/24
19				X				Blows: 7, 13, 19, 23
20								

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330
BORING NUMBER: 8200-MPF
RIG TYPE: CME 75
TEMPERATURE (°F): 75°F

CLIENT:	AFCEE/AEC/Ft. Carson
BORING DIA.:	8"
CONTRACTOR:	Grand Exploration
WEATHER:	clear, sl breeze from east
DRLG MED:	solid stem sugar

DATE: 7/29/96
ELEVATION:
DATUM:
GEOLOGIST: D. Teets

COMMENTS:

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330
 BORING NUMBER: 8200-XWS MFG
 RIG TYPE: Geo probe
 TEMPERATURE (°F): BCF

CLIENT: AFCEE/AEC/Ft. Carson
 BORING DIA.: 11-inch 2-inch
 CONTRACTOR: Ground Exploration Parsons ES
 WEATHER:
 DRLG MED: HSA - Direct push

DATE: 07/26/96
 ELEVATION:
 DATUM:
 GEOLOGIST: D. Teets

COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13			12-13': Clay, dk brn, v dense, no odor or staining		X			② 12 15.5 14.7
14			13.0'-13.5': Silt, sandy, fcc, smclay, tr gravel, brn, dry; no odor or staining		X			② 13 18.0 2.6
15			14-15': Clay, salty, sm calcite, dry, dk brn, no odor or staining		X			③ 15' 10.2 2.9
16			16-18': Clay, sm calcite, moist, brn, no odor or staining		X			④ 18' 18.0 8.0
17			18-19': SAA		X			⑤ 19.5' 7.7
18			19-19.5' SAA except bil staining, & pet. calcar present, v moist		X			⑥ 20' 25.8/4.2
19								
20			20-22': Clay, sm calcite, moist, brn, slight odor, no staining					

PID - Photoionization Detector

bgs - Below Ground Surface

BH - Borehole

na - Not Analyzed

SAA - Same As Above

ppmv - Parts per Million, Volume per Volume

Bkgrnd - Background

HS - Sample Headspace

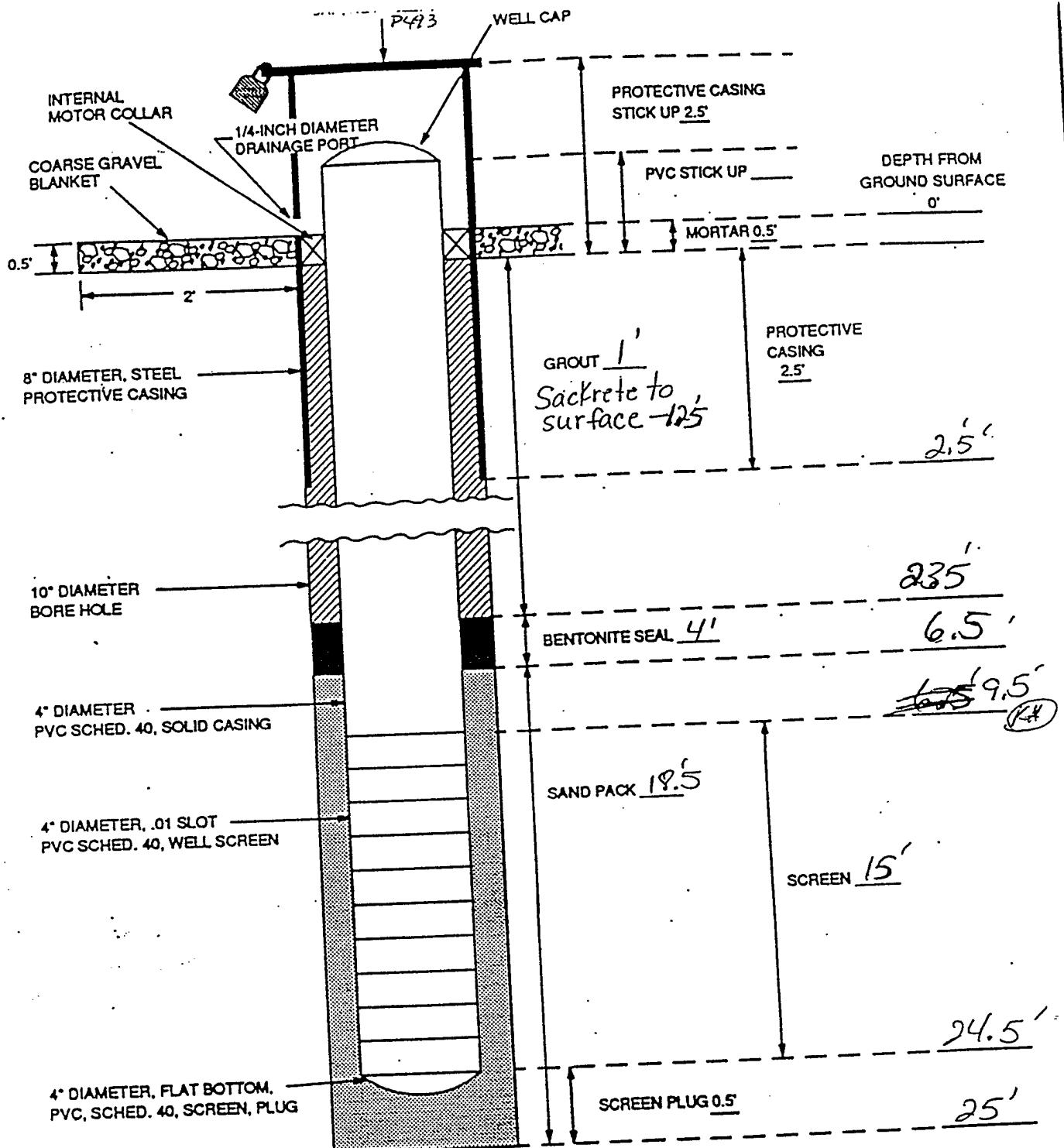
HSA - Hollow Stem Auger

SS - Split Spoon Sample

ft - Feet

BS - Brass Sleeve Sample

② 22
67.2/4.5
G - Grab Sample



**WELL CONSTRUCTION DIAGRAM
ABOVE GROUND GROUNDWATER MONITORING WELL**

SITE: FORT CARSON

DATE START: 7-21-92

TOTAL DEPTH: 25'

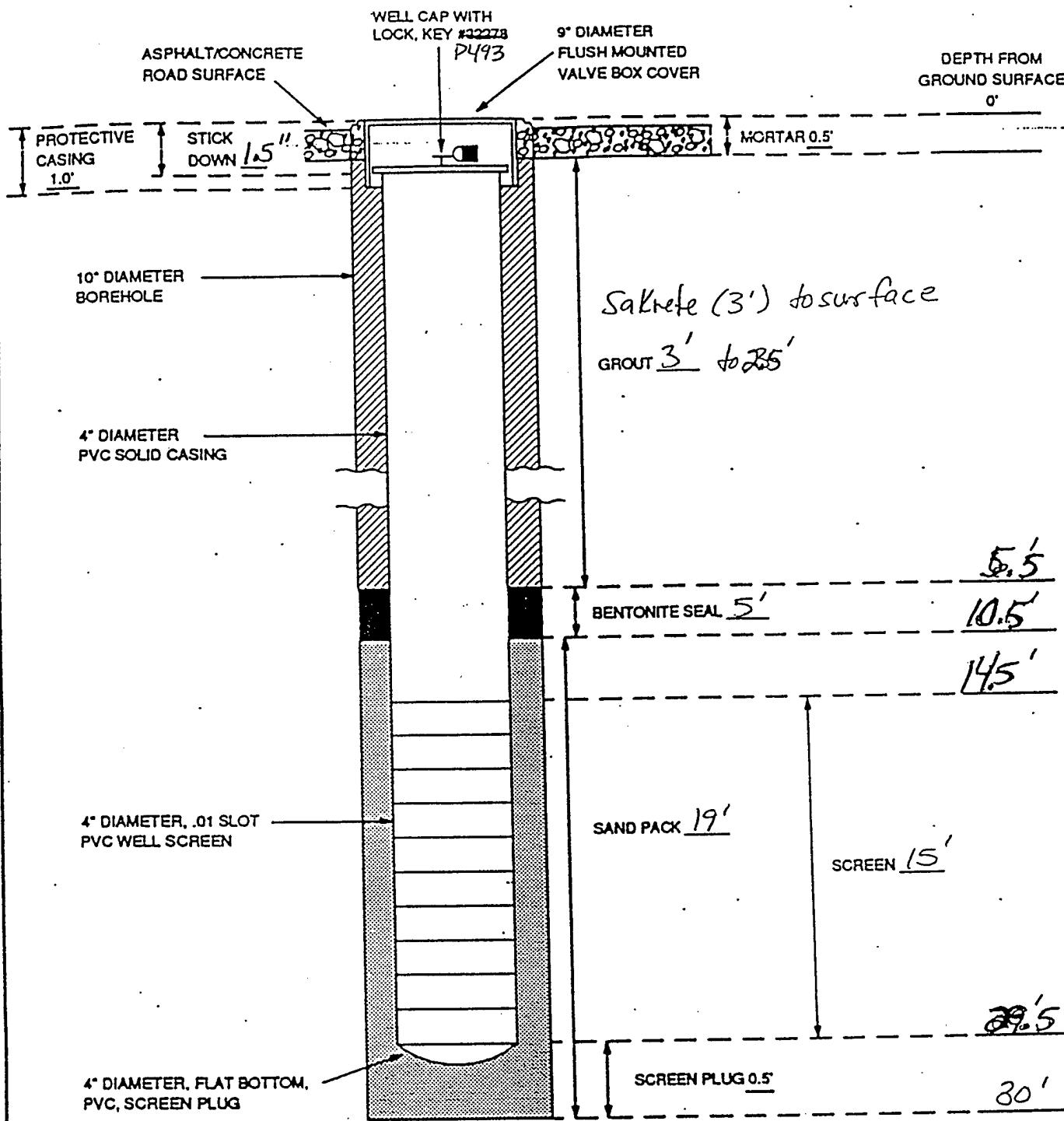
WELL NUMBER: ~~FCMW~~ FCMW-89

DATE FINISH: 7-22-92

GEOLOGIST: K. Hanson

NOT TO SCALE

Bids. 8200



**WELL CONSTRUCTION DIAGRAM
FLUSH MOUNT GROUNDWATER MONITORING WELL**

SITE: FORT CARSON

DATE START: 7-21-92

TOTAL DEPTH: 30'

WELL NUMBER: FCmW-88.

DATE FINISH: 7-22-92

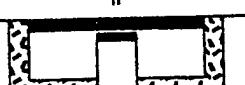
GEOLOGIST: K. Hanson

NOT TO SCALE

Bldg. 8200

HTW DRILLING LOG

HOLE NO: 8200-MM1

1. COMPANY NAME RUST Environment & Infrastructure, Englewood, CO							2. DRILLING SUBCONTRACTOR Site Services Inc, Golden, CO		SHEET 1 OF 2			
3. PROJECT 87533.200 Fort Carson - Multiple USTs				4. LOCATION Motor Pool #8200								
5. NAME OF DRILLER Anthony Rodriguez				6. MANUFACTURER'S DESIGNATION OF DRILL CME-75								
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		8" outside diameter		8. HOLE LOCATION East of westernmost pump island								
		Hollow Stem Auger										
		Continuous Core		9. SURFACE ELEVATION 5844.18 N: 762158.3349 E: 220552.4357								
				10. DATE STARTED June 29, 1994								
12. OVERBURDEN THICKNESS: 20.0				15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) 9.0								
13. DEPTH DRILLED INTO ROCK: 0.0				16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED 9.96 7/21/94								
14. TOTAL DEPTH OF HOLE (in ft. bgs): 20.0				17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)								
18. GEOTECHNICAL SAMPLES 15-18, 10-13		DISTURBED X		UNDISTURBED		19. TOTAL NUMBER OF CORE BOXES						
20. SAMPLES FOR CHEMICAL ANALYSIS 8-10, 10-13, 15-18		VOC X		METALS Total Pb/Cr		OTHER (SPECIFY) TCO		OTHER (SPECIFY) PCBs		21. TOTAL CORE RECOVERY 100 %		
22. DISPOSITION OF HOLE G.W. Monitoring Well		BACKFILLED		MONITORING WELL 8200-SBI		OTHER (SPECIFY)		23. SIGNATURE OF INSPECTOR Ken Pill, Robin Christians				
DEPTH <i>a</i>	USCS <i>b</i>	DESCRIPTION OF MATERIALS <i>c</i>		FIELD SCREENING RESULTS <i>d</i>		GEOTECH SAMPLE OR CORE BOX NO. <i>e</i>		ANALYTICAL SAMPLE NO. <i>f</i>		REMARKS <i>g</i>		MONITORING WELL DIAGRAM <i>h</i>
1	CL	10" Concrete at surface.		0 ppm						5 Sand 20 Silt 75 Clay		
2		Stiff, very dark grayish brown, SILTY CLAY, trace fine sand, slightly moist.		695 ppm								
3				1000+ ppm								
5		Soft, very dark grayish brown, SILTY CLAY, thinly laminated, slightly indurated, trace fine sand, trace clay, orange staining on fracture faces, moist.		8200-SBI 8'- 10'						Hydrocarbon odor starting at 5' bgs. 5 Sand 90 Silt 5 clay		
6												
7	ML											
8												
9												

PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-MM1

HTW DRILLING LOG

HOLE NO: 8200-MM1

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

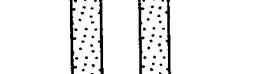
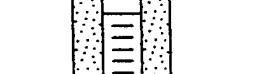
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h
10	CH	Medium stiff, dark gray (10 YR 4/1), SILTY CLAY, moist.					
11		SILTY CLAY, orange staining, gypsum, strong odor.	1000+ ppm	10'-13'	8200-SBI 10'-13'	0 Sand 20 Silt 80 Clay Strong hydrocarbon odor, staining.	
12							
13							
14		Blocky fractures with product between fractures.	1000+ ppm				
15	CL					Strong odor, possible product.	
16		Soft, light yellowish brown (10 YR 8/4), SILTY CLAY, few fine-to coarse-grained sand, moist.	1000+ ppm	15'-18'	8200-SBI 15'-18'		
17							
18							
19							
20		TOTAL DEPTH = 20 FEET BGS					
21							
22							
23							
24							
25							
26							
27							
28							
29							

 PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-MM1

HTW DRILLING LOG

HOLE NO: 8200-MW2

HTW DRILLING LOG							HOLE NO: 8200-MW2			
1. COMPANY NAME RUST Environment & Infrastructure, Englewood, CO			2. DRILLING SUBCONTRACTOR Site Services Inc., Golden, CO				SHEET 1 OF 2			
3. PROJECT 87533.200 Fort Carson - Multiple USTs			4. LOCATION Motor Pool #8200							
5. NAME OF DRILLER Anthony Rodriguez			6. MANUFACTURER'S DESIGNATION OF DRILL CME-75							
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		8" outside diameter		8. HOLE LOCATION West of easternmost pump island						
		Hollow Stem Auger		9. SURFACE ELEVATION 5843.98 N: 762154.5619 E: 2205691.933						
		Continuous Core		10. DATE STARTED July 5, 1994						
12. OVERBURDEN THICKNESS: 18.5			15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) 10							
13. DEPTH DRILLED INTO ROCK: 0.0			16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED 9.18 7/2/94							
14. TOTAL DEPTH OF HOLE (in ft. bgs): 18.5			17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) NA							
18. GEOTECHNICAL SAMPLES 5-8, 10-13		DISTURBED <input checked="" type="checkbox"/>		UNDISTURBED		19. TOTAL NUMBER OF CORE BOXES				
20. SAMPLES FOR CHEMICAL ANALYSIS 5-8, 8-10, 10-13		VOC <input checked="" type="checkbox"/>		METALS Total Pb/Cr		OTHER (SPECIFY) TCO		OTHER (SPECIFY) PCBs	OTHER (SPECIFY) Oil & Grease	21. TOTAL CORE RECOVERY 100 %
22. DISPOSITION OF HOLE G.W. Monitoring Well		BACKFILLED		MONITORING WELL 8200-MW2		OTHER (SPECIFY)		23. SIGNATURE OF INSPECTOR Ken Pill, Robin Christians		
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c		FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g		MONITORING WELL DIAGRAM h	
1	ML	12" Concrete at surface		0 ppm			Hydrocarbon staining and odors at 2'.			
2		Stiff, dark brown, SILTY CLAY, iron staining, calcite present, dry.		0 ppm			80% Recovery 60 Silt 35 Clay 5 Sand			
3				5'- 8'	8200-SB2 5'- 8'		100% Recovery 55 Silt 45 Clay 5 Sand			
4				0 ppm						
5				0 ppm						
6				0 ppm						
7				0 ppm						
8				0 ppm						
9		Very stiff, dark brown, SILTY CLAY, iron staining, calcite present, dry.		0 ppm	8200-SB2 8'-10'					

PROJECT **87533.200**
Fort Carson - Multiple USTs

HOLE NO. **8200-MW2**

HTW DRILLING LOG

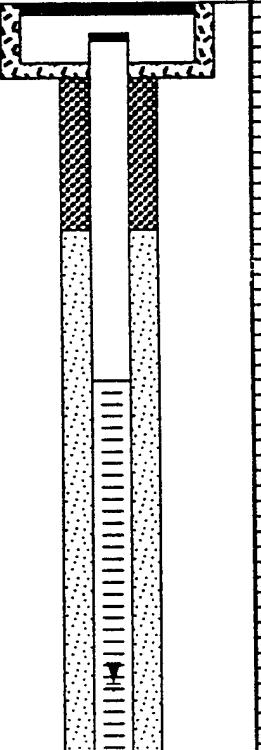
HOLE NO: 8200-MW2

SHEET 2 OF 2 SHEET (S)

PROJECT 87533.200 Fort Carson - Multiple USTs		INSPECTOR					
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h
11	ML	Stiff to firm, dark brown, SILTY CLAY, iron staining, slightly moist. Very moist at 11.5' (2" layer)	0 ppm	10'- 13'	8200-SB2 10'- 13'		
12							
13							
14		Very soft, dark brown, SILTY CLAY, iron staining, fractured, saturated.	0 ppm				
15							
16	CL	Stiff, dark brown, SILTY CLAY, iron staining.	0 ppm				
17							
18							
19		TOTAL DEPTH = 18.5 FEET BGS					
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

HTW DRILLING LOG

HOLE NO: 8200-MM3

1. COMPANY NAME RUST Environment & Infrastructure, Englewood, CO						2. DRILLING SUBCONTRACTOR Site Services Inc., Golden, CO		SHEET 1 OF 2		
3. PROJECT 87533.200 Fort Carson - Multiple USTs			4. LOCATION Motor Pool #8200							
5. NAME OF DRILLER Anthony Rodriguez			6. MANUFACTURER'S DESIGNATION OF DRILL CME-75							
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		8" outside diameter		8. HOLE LOCATION North of easternmost pump island						
		- Hollow Stem Auger								
		Continuous Core		9. SURFACE ELEVATION 5844.72 N: 762191.4033 E: 2205742.8853						
				10. DATE STARTED July 5, 1994						
12. OVERBURDEN THICKNESS: 15.0			15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) 8.0							
13. DEPTH DRILLED INTO ROCK: 0.0			16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED 9.96 7/21/94							
14. TOTAL DEPTH OF HOLE (in ft. bgs): 15.0			17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) NA							
18. GEOTECHNICAL SAMPLES		DISTURBED 5-8, 10-13	UNDISTURBED X	19. TOTAL NUMBER OF CORE BOXES						
20. SAMPLES FOR CHEMICAL ANALYSIS		VOC 3-8, 8-13	METALS Total Pb/Cr	OTHER (SPECIFY) TCO	OTHER (SPECIFY) PCBs	OTHER (SPECIFY) Oil & Grease	21. TOTAL CORE RECOVERY 100 %			
22. DISPOSITION OF HOLE		BACKFILLED G.W. Monitoring Well	MONITORING WELL 8200-MM3	23. SIGNATURE OF INSPECTOR Ken P.M. Robin Christians						
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	MONITORING WELL DIAGRAM h			
1	CL	14" Concrete at surface.	0 ppm	5'- 8'	8200-SB3 8'-10'	100% Recovery 100 % Recovery				
2										
3										
4										
5										
6										
7										
8										
9										

HTW DRILLING LOG							HOLE NO: 8200-MW3
PROJECT 87533.200 Fort Carson - Multiple USTs			INSPECTOR				SHEET 2 OF 2 SHEET (S)
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h
11	CL	Very stiff, dark brown/black, SILTY CLAY with coarse-sand size gypsum crystals continuous throughout core, hydrocarbon staining continuous through core, saturated, fractured.	0 ppm	10'- 13'	8200-SB3 10'-13'	96 Silt/Clay 5 Sand	
13		Stiff, dark brown/black, SILTY CLAY, hydrocarbon staining continuous through core, saturated.	0 ppm		8200-SB3 13'-15'		
15		TOTAL DEPTH = 15 FEET BGS					
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

HTW DRILLING LOG						HOLE NO: 8200-MW4	
1. COMPANY NAME <i>RUST Environment & Infrastructure, Englewood, CO</i>			2. DRILLING SUBCONTRACTOR <i>Site Services Inc., Golden, CO</i>			SHEET 1 OF 2	
3. PROJECT <i>87533.200 Fort Carson - Multiple USTs</i>			4. LOCATION <i>Motor Pool #8200</i>				
5. NAME OF DRILLER <i>Anthony Rodriguez</i>			6. MANUFACTURER'S DESIGNATION OF DRILL <i>CME-75</i>				
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		<i>8" outside diameter</i>	8. HOLE LOCATION <i>North of fence, east of tanks.</i>				
		<i>Hollow Stem Auger</i>					
		<i>Continuous Core</i>	9. SURFACE ELEVATION <i>5846.79</i> N: <i>762273.6003</i> E: <i>2205876.5415</i>				
			10. DATE STARTED <i>July 6, 1994</i>				
12. OVERBURDEN THICKNESS: <i>15.0</i>			15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) <i>9.5</i>				
13. DEPTH DRILLED INTO ROCK: <i>0.0</i>			16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED <i>14.21 7/22/94</i>				
14. TOTAL DEPTH OF HOLE (in ft. bgs): <i>15.0</i>			17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) <i>NA</i>				
18. GEOTECHNICAL SAMPLES <i>5-8, 10-13</i>		DISTURBED <i>X</i>	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
20. SAMPLES FOR CHEMICAL ANALYSIS <i>8-10, 10-13, 13-15</i>		VOC <i>X</i>	METALS <i>Total Pb/Cr</i>	OTHER (SPECIFY) <i>TCO</i>	OTHER (SPECIFY) <i>PCBs</i>	OTHER (SPECIFY) <i>Oil & Grease</i>	2L TOTAL CORE RECOVERY <i>100 %</i>
22. DISPOSITION OF HOLE <i>G.W. Monitoring Well</i>		BACKFILLED	MONITORING WELL <i>8200-MW4</i>	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR <i>Ken Pitt, Robin Christians</i>		
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	MONITORING WELL DIAGRAM h
-4							
-3							
-2							
-1							
0		Topsoil and cobbles	0 ppm				
1							
2							
3	CL	Very stiff, dark brown, SILTY CLAY, gypsum present, slightly moist.	0 ppm			100% Recovery 10 Sand 40 Silt 50 Clay	
4							

PROJECT *87533.200*
Fort Carson - Multiple USTs

HOLE NO. *8200-MW4*

HTW DRILLING LOG

HOLE NO: 8200-MW4

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

DEPTH ft	USCS D	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h
6			0 ppm	5'- 8'			
7							
8		CLAY, as above, except moist.					
9		Very stiff/hard, dark brown, SILTY CLAY, gypsum present continuous through core, dry.	0 ppm		8200-SB4 8'-10'	5 Sand 35 Silt 60 Clay	
10	CL	Very hard, dark brown SILTY CLAY, iron staining, gypsum present, very moist.				40 Silt 5 Sand 35 Clay	
11			0 ppm	10'- 13'	8200-SB4 10'-13'		
12							
13		Hard, dark brown/black, SILTY CLAY, weathered, iron staining, saturated.	0 ppm		8200-SB4 13'-15'	100% Recovery 40 Silt 5 Sand 55 Clay	
14							
15		TOTAL DEPTH = 15 FEET BGS					
16							
17							
18							
19							
20							
21							
22							
23							
24							

HTW DRILLING LOG

HOLE NO: 8200-MW5

1. COMPANY NAME <i>RUST Environment & Infrastructure, Englewood, CO</i>						2. DRILLING SUBCONTRACTOR <i>Site Services Inc., Golden, CO</i>		HOLE NO: 8200-MW5	
3. PROJECT <i>87533.200 Fort Carson - Multiple USTs</i>				4. LOCATION <i>Motor Pool #8200</i>					
5. NAME OF DRILLER <i>Anthony Rodriguez</i>				6. MANUFACTURER'S DESIGNATION OF DRILL <i>CME-75</i>					
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		<i>8" outside diameter</i>		8. HOLE LOCATION <i>Northwest of USTs</i>					
		<i>Hollow Stem Auger</i>							
		<i>Continuous Core</i>		9. SURFACE ELEVATION <i>5848.23</i> N: <i>762327.3746</i> E: <i>2205505.0599</i>					
				10. DATE STARTED <i>July 6, 1994</i>					
12. OVERBURDEN THICKNESS: <i>20.0</i>				15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) <i>18.5</i>					
13. DEPTH DRILLED INTO ROCK: <i>0.0</i>				16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED <i>20.59 7/28/94</i>					
14. TOTAL DEPTH OF HOLE (in ft. bgs): <i>20.0</i>				17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) <i>NA</i>					
18. GEOTECHNICAL SAMPLES <i>5-8, 10-13</i>			DISTURBED <input checked="" type="checkbox"/>	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES				
20. SAMPLES FOR CHEMICAL ANALYSIS <i>8-10, 10-13, 15-18</i>			VOC <input checked="" type="checkbox"/>	METALS <i>Total Pb/Cr</i>	OTHER (SPECIFY) <i>TCO</i>	OTHER (SPECIFY) <i>PCBs</i>	OTHER (SPECIFY) <i>Oil & Grease</i>	21. TOTAL CORE RECOVERY <i>100 %</i>	
22. DISPOSITION OF HOLE <i>G.W. Monitoring Well</i>			BACKFILLED	MONITORING WELL <i>8200-MW5</i>	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR <i>Ken PW, Robin Christians</i>			
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	MONITORING WELL DIAGRAM h		
-4									
-3									
-2									
-1									
0		<i>Topsoil and cobbles.</i>	<i>0 ppm</i>						
1									
2									
3	CL	<i>Hard, dark brown, SILTY CLAY; iron staining, dry.</i>	<i>0 ppm</i>			<i>100% Recovery 20 Sand 30 Silt 50 Clay</i>			
4									

PROJECT *87533.200*
Fort Carson - Multiple USTs

HOLE NO. *8200-MW5*

HTW DRILLING LOG

HOLE NO. 8200-MW5

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS D	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h
6			0 ppm	5'- 8'		80 Silt/Clay 20 Sand	
7			0 ppm				
8		Hard, dark brown, SILTY CLAY, iron staining, dry.	0 ppm		8200-SB5 8'-10'		
9			0 ppm				
10			0 ppm	10'- 13'	8200-SB5 10'-13'	30 Silt 20 Sand 50 Clay	
11			0 ppm				
12			0 ppm				
13	CL	Very stiff, dark brown, SILTY CLAY, fractured, dry, iron staining continues, calcareous veining present.	0 ppm			100% Recovery 45 Silt 5 Sand 50 Clay	
14			0 ppm				
15		Very stiff, medium gray, CLAY, possible bentonite, slightly moist.	0 ppm				
16			0 ppm				
17		Very stiff, dark brown, SILTY CLAY, slightly moist, calcareous veining.	0 ppm		8200-SB5 15'-18'		
18			0 ppm				
19			0 ppm				
20		TOTAL DEPTH = 20 FEET BGS					
21							
22							
23							
24							

 PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-MW5

HTW DRILLING LOG							HOLE NO: 8200-SB8
1. COMPANY NAME RUST Environment & Infrastructure, Englewood, CO			2. DRILLING SUBCONTRACTOR Site Services Inc, Golden, CO				SHEET 1 OF 2
3. PROJECT 87533.200 Fort Carson - Multiple USTs			4. LOCATION Motor Pool #8200				
5. NAME OF DRILLER Anthony Rodriguez			6. MANUFACTURER'S DESIGNATION OF DRILL CME-75				
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		8" outside diameter	8. HOLE LOCATION Immediately south of tanks.				
		Hollow Stem Auger					
		Continuous Core	9. SURFACE ELEVATION 5844.73 N: 762196.9835 E: 2205562.2940				
			10. DATE STARTED July 7, 1994				
12. OVERBURDEN THICKNESS: 11.0			15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) 8'-8.5'				
13. DEPTH DRILLED INTO ROCK: 2.0			16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED NA				
14. TOTAL DEPTH OF HOLE (in ft. bgs): 13.0			17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) NA				
18. GEOTECHNICAL SAMPLES NA		DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
20. SAMPLES FOR CHEMICAL ANALYSIS 5-8, 8-10, 10-13		VOC X	METALS Total Pb/Cr	OTHER (SPECIFY) TCO	OTHER (SPECIFY) PCBs	OTHER (SPECIFY) Oil & Grease	21. TOTAL CORE RECOVERY 100 %
22. DISPOSITION OF HOLE		BACKFILLED X	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR Ken Pil, Robin Christians		
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1	CL	Concrete at surface.	0 ppm	8200-SB8 5'-8'	8200-SB8 8'-10'		15 Sand 35 Silt 50 Clay
2		Soft, dark brown, SILTY CLAY, occasional calcareous veining, occasional gypsum crystals, iron staining, weathered, slightly moist, fractured.					
3							
4							
5							
6							
7							
8							
9		Stiff, dark brown, SILTY CLAY, gypsum, iron staining, slightly moist.					

PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-SB8

HTW DRILLING LOG

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

HOLE NO: 8200-SB6

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	CL	Stiff, medium tan, CLAY (bentonitic?), slightly moist.	0 ppm		8200-SB6 10'-13'		
12	SiltSt	Hard, dark brown, SILTSTONE, calcite veining continuous throughout core, moist to dry.					
13		TOTAL DEPTH = 13 FEET BGS					
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-SB6

HTW DRILLING LOG

HOLE NO. 8200-S87

HTW DRILLING LOG							HOLE NO. 8200-S87	
1. COMPANY NAME RUST Environment & Infrastructure, Englewood, CO				2. DRILLING SUBCONTRACTOR Site Services Inc., Golden			SHEET 1 OF 2	
3. PROJECT 87533.200 Fort Carson - Multiple USTs				4. LOCATION Motor Pool #8200				
5. NAME OF DRILLER Anthony Rodriguez				6. MANUFACTURER'S DESIGNATION OF DRILL CME-75				
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8" outside diameter			8. HOLE LOCATION Northeast of tanks.				
	Hollow Stem Auger							
	Continuous Core			9. SURFACE ELEVATION 5845.82 N: 762243.8111 E: 2205678.3959				
				10. DATE STARTED July 7, 1994				
12. OVERBURDEN THICKNESS: 11.5				15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) 8.0				
13. DEPTH DRILLED INTO ROCK: 15				16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED NA				
14. TOTAL DEPTH OF HOLE (in ft. bgs): 13.0				17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) NA				
18. GEOTECHNICAL SAMPLES NA		DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES				
20. SAMPLES FOR CHEMICAL ANALYSIS (3)		VOC <input checked="" type="checkbox"/>	METALS Total Pb/Cr	OTHER (SPECIFY) TCO	OTHER (SPECIFY) PCBs	OTHER (SPECIFY) Oil & Grease	21. TOTAL CORE RECOVERY 100 %	
22. DISPOSITION OF HOLE		BACKFILLED <input checked="" type="checkbox"/>	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR Ken PHL, Robin Christians			
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c		FIELD SCREENING RESULTS d	GEO TECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		Gravel at surface.		0 ppm	8200-S87 5'-8'	8200-S87 8'-10'		
1		Soft, dark brown (7.5 YR 3/2), CLAYEY SILT, few % clay, blocky fractures, stains on faces, gypsum present, slightly indurated, slightly moist.						
2								
3								
4								
5	ML							
6								
7								
8		Hard, very dark gray (7.5 YR 3/0), CLAYEY SILT, blocky fractures with THW laminations, orange stained on fracture faces, gypsum crystals along fractures, indurated, moist.						
9								

PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-S87

HTW DRILLING LOG

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

HOLE NO: 8200-S87

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	ML	Soft, strong brown (7.5 YR 5/8), SILTY CLAY, trace fine- to medium-grained sand, wet.					
12	Siltst	SILTSTONE, saturated at 11.5' bgs.	0 ppm		8200-S87 10'-13'		
13		TOTAL DEPTH = 13 FEET BGS					
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-S87

HTW DRILLING LOG							HOLE NO: 8200-SB8	
1. COMPANY NAME RUST Environment & Infrastructure, Englewood, CO			2. DRILLING SUBCONTRACTOR Site Services Inc., Golden, CO				SHEET 1 OF 2	
3. PROJECT 87533.200 Fort Carson - Multiple USTs			4. LOCATION Motor Pool #8200					
5. NAME OF DRILLER Anthony Rodriguez			6. MANUFACTURER'S DESIGNATION OF DRILL CME-75					
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		8" outside diameter		8. HOLE LOCATION 50' west of MW-1				
		Hollow Stem Auger						
		Continuous Core		9. SURFACE ELEVATION 5845.27 N 762150.0683 E: 2205463.7979				
				10. DATE STARTED July 14, 1994				
				11. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs)				
				12. DEPTH DRILLED INTO ROCK: 0.5				
13. DEPTH DRILLED INTO ROCK: 0.5			14. TOTAL DEPTH OF HOLE (in ft. bgs): 12.5					
15. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED NA			16. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) NA					
17. GEOTECHNICAL SAMPLES NA		DISTURBED	UNDISTURBED	18. TOTAL NUMBER OF CORE BOXES				
20. SAMPLES FOR CHEMICAL ANALYSIS 3		VOC X	METALS Total Pb/Cr	OTHER (SPECIFY) TCO	OTHER (SPECIFY) PCBs	OTHER (SPECIFY) Oil & Grease	21. TOTAL CORE RECOVERY 100 %	
22. DISPOSITION OF HOLE Vertical		BACKFILLED X	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR Ken Pil, Robin Christians			
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h	
1		Concrete at surface.	0 ppm	8200-SB8 3'-4'	8200-SB8 6'-7'			
2		Firm, brown, CLAY with some silt, trace micaceous sand, some interbedded intervals of gravelly clay, moist, no hydrocarbon odor or staining.						
3								
4								
5	CL	Firm, brown to dark brown, gravelly CLAY, moist.	0 ppm	8200-SB8 6'-7'				
6								
7								
8								
9								

PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-SB8

HTW DRILLING LOG							HOLE NO: 8200-SB8
PROJECT 87533.200 Fort Carson - Multiple USTs		INSPECTOR					SHEET 2 OF 2 SHEET (S)
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	CL	Firm, dark brown, gravelly CLAY, gravel is all shale, some large chert gravel, moist.	0 ppm			8200-SB8 11'-12'	
12	SHSt	BEDROCK, dark brown, hard, shale.					
13		TOTAL DEPTH = 12.5 FEET BGS.					
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-SB8

HTW DRILLING LOG

HOLE NO: 8200-SB9

1. COMPANY NAME RUST Environment & Infrastructure, Englewood, CO 2. DRILLING SUBCONTRACTOR Site Services Inc, Golden, CO SHEET 1 OF 2

3. PROJECT 87533.200 Fort Carson - Multiple USTs				4. LOCATION Motor Pool #8200			
5. NAME OF DRILLER Anthony Rodriguez				6. MANUFACTURER'S DESIGNATION OF DRILL CME-75			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8" outside diameter			8. HOLE LOCATION 40' southeast of easternmost dispenser island.			
	Hollow Stem Auger						
	Continuous Core			9. SURFACE ELEVATION 5843.27 N: 762082.2550 E: 2205776.1440			
				10. DATE STARTED July 14, 1994			
12. OVERBURDEN THICKNESS: 5.0				15. DEPTH GROUNDWATER ENCOUNTERED (in ft bgs)			
13. DEPTH DRILLED INTO ROCK: 8.0				16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED			
14. TOTAL DEPTH OF HOLE (in ft bgs): 13.0				17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)			
18. GEOTECHNICAL SAMPLES NA		DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
20. SAMPLES FOR CHEMICAL ANALYSIS 3-4, 8-9, 11-13		VOC <input checked="" type="checkbox"/>	METALS Total Pb/Cr	OTHER (SPECIFY) TCO	OTHER (SPECIFY) PCBs	OTHER (SPECIFY) Oil & Grease	2L TOTAL CORE RECOVERY 100 %
22. DISPOSITION OF HOLE		BACKFILLED <input checked="" type="checkbox"/>	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR Ken Pitt, Robin Christians		
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1	CL	Concrete at surface.	0 ppm	8200-SB9 3'- 4'			
2		Firm, brown, SANDY CLAY, sand is micaceous, some calcite present, moist.	0 ppm				
3			0 ppm				
4			0 ppm				
5		- WEATHERED BEDROCK - CLAYSTONE, hard, stratified, some iron staining, layering = 2mm thick.	0 ppm				
6	SiltSt		0 ppm	8200-SB9 8'- 9'			
7			0 ppm				
8			0 ppm				
9			0 ppm				

PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-SB9

HTW DRILLING LOG						HOLE NO: 8200-SB9	
PROJECT 87533.200 Fort Carson - Multiple USTs			INSPECTOR	SHEET 2 OF 2 SHEET(S)			
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	Silt	CLAYSTONE as above, except stratification not as evident, very moist at 13'.	0 ppm		8200-SB9 12'- 13'		
12		No odor or stain.	0 ppm				
13		TOTAL DEPTH = 13 FEET BGS					
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200
Fort Carson - Multiple USTs

HOLE NO. 8200-SB9

HTW DRILLING LOG

HOLE NO: 8200-SB10

HTW DRILLING LOG							HOLE NO: 8200-SB10		
1. COMPANY NAME RUST Environment & Infrastructure, Englewood, CO			2. DRILLING SUBCONTRACTOR Site Services Inc, Golden, CO				SHEET 1 OF 2		
3. PROJECT 87533.200 Fort Carson - Multiple USTs			4. LOCATION Motor Pad #8200						
5. NAME OF DRILLER Anthony Rodriguez			6. MANUFACTURER'S DESIGNATION OF DRILL CME-75						
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		8" outside diameter		8. HOLE LOCATION North of east building edge.					
		Hollow Stem Auger							
		Continuous Core		9. SURFACE ELEVATION 5844.1752 N: 762216.6271 E: 2205788.7464					
				10. DATE STARTED July 25, 1994					
12. OVERBURDEN THICKNESS: NA			15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs)						
13. DEPTH DRILLED INTO ROCK: NA			16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED 10'-10.5' NA						
14. TOTAL DEPTH OF HOLE (in ft. bgs): 13.0			17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) NA						
18. GEOTECHNICAL SAMPLES NA		DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES NA					
20. SAMPLES FOR CHEMICAL ANALYSIS		VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	2L TOTAL CORE RECOVERY	X	
22. DISPOSITION OF HOLE		BACKFILLED X	MONITORING WELL	OTHER (SPECIFY)		23. SIGNATURE OF INSPECTOR Ken Pill, Robin Christians			
DEPTH b	USCS d	DESCRIPTION OF MATERIALS c		FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h	
1	CL	Concrete at surface.		0 ppm					
2				0 ppm					
3		Firm, medium brown, SILTY CLAY with gypsum pockets, slightly moist.		0 ppm					
4	CL			0 ppm					
5				0 ppm					
6				0 ppm					
7				0 ppm					
8	ML	Firm to very firm, medium dark brown, SANDY SILT with gypsum pockets, slightly moist.		0 ppm	8200-SB10 5'-8'				
9				0 ppm	8200-SB10 8'-10'			Sand 25% Silt 45% Clay 30%	

PROJECT **87533.200**
Fort Carson - Multiple USTs

HOLE NO. **8200-SB10**

HTW DRILLING LOG							HOLE NO: 8200-S810
PROJECT 87533.200 Fort Carson - Multiple USTs			INSPECTOR			SHEET 2 OF 2 SHEET (S)	
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	CL	Slightly soft, medium brown/organic, SILTY CLAY, hematite staining, gypsum pockets, saturated at 10.5'.	0 ppm		8200-S810 10'-13'		Sand 5% Silt 45% Clay 50%
12		Slightly firm, medium brown, SILTY CLAY, hematite staining and gypsum pockets, no staining slightly moist, faint hydrocarbon odor at 13'.	25 ppm				Faint hydrocarbon odor at 13'; no visible staining.
13		TOTAL DEPTH = 13.0 FEET BGS					
14							
15							
16							
17							
18							
19							
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22							
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Inchcape Testing Services Environmental Laboratories 103S East Colms Blvd., #100 Richardson, TX 75081 (214) 238-5591

Report to:		Invoice to		ANALYSIS REQUESTED	
Company: Parsons Engineering Service	Company: _____	Address: _____	Address: _____		
Address: 1700 Broadway Ste 900					
Denver, CO 80220					
Contact: Dave Teets	Contact: <u>Bob Riecken</u>	Phone: (303) 831-8100	Phone: _____	PO/SO #: 726876.73330	PO/SO #: _____
Phone: (303) 831-8208		Fax: (303) 831-8208			
Sampler's Name DAVID TEETS	Sampler's Signature <i>Dave Teets</i>				
Proj. No. 726876.73330	Project Name AFCET Bioventing - First Carson, Colo.				
Matrix ¹	Date	Time	C o n t a i n e r s p a b	Identifying Marks of Sample(s)	
S	7/14/01	10:55	X	8200-MPA-20	
	7/16/01	10:55	X	8200-mpa-21	
	7/17/01	10:50	X	8200-MPC-21	
	7/23/01	11:05	X	8200-MPD-15.5	
	7/23/01	15:55	X	8200-VW2-16	
	7/23/01	16:10	X	8200-MPD-9	
	7/22/01	13:45	X	8200-BG-11	
	7/24/01	11:10	X	8200-MPF-15	
	7/24/01	11:15	X	8200-MPF-17	
	7/24/01	15:25	X	8200-MPE-17.5	
Turn around time		<input checked="" type="checkbox"/> Priority 1 or Standard	<input type="checkbox"/> Priority 2 or 50%	<input type="checkbox"/> Priority 3 or 100%	<input type="checkbox"/> Priority 4 ERS *
Relinquished by: (Signature) <i>Dave Teets</i>	Date: 7/24/01	Time: 1900	Received by: (Signature) <i>JBD LR</i>	Date: 7/25/01	Time: 1625
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature) <i>B. W. Dillman</i>	Date:	Time:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
* BTEX (602/8020) TPH (418.1 & 8015) VOLATILES (624/8240), IGNITABILITY, TOTAL LEAD (6010)					
Remarks <u>OPTION 3 Reporting</u>					
Client's delivery of samples constitutes acceptance of Inchcape/TS-Dallas terms and conditions contained in the Price Schedule.					

OFFICE USE ONLY
ORIGINAL

Inchcape cannot accept verbal changes.
Please Fax written changes to
214-238-5592

1 Matrix WW - Wastewater
2 Container VOA - 40 ml vial
W - Water S - Soil SD - Solid L - Liquid A - Air Bag
A/G - Amber / Or Glass 1 Liter 250 ml - Glass wide mouth
C - Charcoal tube SL - Sludge O - Oil
P/O - Plastic or other



AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

CHAIN-OFF-CUSTODY RECORD

Nº 007721 Page 1 of 1

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

Contact Person <u>Dave Teets</u>	Project info: P.O. # <u>726876-73330</u>			Turn Around Time: <input checked="" type="checkbox"/> Normal <input type="checkbox"/> Rush _____ Specify _____
Company <u>Parson's Engineering Science Inc.</u>	Project # <u>SAA</u>	State <u>CO</u> Zip <u>80220</u>	Phone Name <u>Fort Carson Bioventing</u>	
Address <u>1700 Broadway Ste 900</u>	City <u>Denver</u>			
Phone <u>(303) 831-8100</u>	FAX <u>(303) 831-8208</u>			
Collected By: Signature _____				
Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial Final Receipt
01A	8200-YWJ3	7/25/96 0925	J0-3	4.5 1/2
02A	8200-MPD-18	7/25/96 1120		5.5 1/2
03A	FCMW89(VW1)	7/25/96 1420		5.5 1/2
04A	8200-MPD-10	7/25/96 1450		5.0 1/2
05A	8200-MW3	7/27/96 1330		4.0 1/2
06A	8200-MPF-12	7/30/96 1000		5.0 1/2
				8/2/96 1/2
Relinquished By: (Signature) <u>Q. Teets</u> Date/Time <u>7/1/96 1500</u> Print Name <u>Dave Teets</u>	Received By: (Signature) Date/Time _____			
Relinquished By: (Signature) <u>Q. Teets</u> Date/Time <u>7/1/96 1500</u>	Received By: (Signature) Date/Time _____			
Relinquished By: (Signature) <u>Q. Teets</u> Date/Time <u>7/1/96 1500</u>	Received By: (Signature) Date/Time _____			
Shipper Name <u>Feed-X</u> Air Bill # <u>1131811820</u>	Opened By: <u>Mark H. Muller</u>	Date/Time <u>7/2/96 1000</u>	Temp. (°C) <u>75</u>	Condition <u>Amber</u>
Lab Use Only				Work Order # <u>9608027</u>

Notes:
Four canisters returned that do not require analysis.

**Initial Respiration Test
Building 8200
Fort Carson, Colorado**

Monitoring Point	Date	Days Elapsed (frac. days)	Time	Hrs elapsed (fractional days)	Days Elapsed (days)	Elapsed Time (min. x 1000)	CO2%	Total Hydro-carbon (%)	Comments	Trend of O2/Time	New x-values (%/minute)	k (%/hour)
MPD-10	07/26/96	0.00	08:30	0.00	0.00	0.00	20.8	0.05	1 min. purge. Helium detector battery low	19.6856136	0	0.000442 0.026542
MPD-10	07/26/96	0.00	09:15	0.03	0.03	0.05	0.75	20.2	0.10	0	0.70	13.2402291 14.57
MPD-10	07/26/96	0.00	11:45	0.14	0.14	0.20	3.25	19.9	0.20	0	1.0	
MPD-10	07/26/96	0.00	16:25	0.33	0.33	0.48	7.92	19.2	1.0	0	2.4	
MPD-10	07/27/96	1.00	09:10	0.03	1.03	1.48	24.67	18.5	0.95	0	4.7	2 min purge.
MPD-10	07/27/96	1.00	15:05	0.27	1.27	1.84	30.53	18.4	1.2	0	3.7	Offgas, in Tedlar.
MPD-10	07/28/96	2.00	10:35	0.09	2.09	3.01	50.03	18.8	1.1	0	2.7	SAA. Took 5 min to fill bag
MPD-10	07/29/96	3.00	08:40	0.01	3.01	4.33	72.17	18.1	1.2	0	3.4	SAA
MPD-10	07/29/96	3.00	19:45	0.47	3.47	5.00	83.25	16.7	1.6	0	NS	SAA
MPD-10	07/30/96	4.00	08:55	0.02	4.02	5.79	96.42	15.7	2.0	0	4.9	SAA
MPD-10	08/05/96	10.00	11:20	0.12	10.12	14.57	242.83	14.0	1.8	0	NS	Very "tight", little sample

MPD-18	07/26/96	0.00	08:33	0.00	0.00	0.00	20.8	0.05	2	1 min. purge. Helium detector battery low	20.3320193	0	0.000773 0.046410	
MPD-18	07/26/96	0.00	09:20	0.03	0.03	0.05	0.78	20.6	0.15	100	0.16	9.06988728 14.56		
MPD-18	07/26/96	0.00	11:50	0.14	0.14	0.20	3.28	20.3	0.35	320	0.42			
MPD-18	07/26/96	0.00	16:31	0.33	0.33	0.48	7.97	20.1	1.0	540	1.00	2 min purge.		
MPD-18	07/27/96	1.00	09:15	0.03	1.03	1.48	24.70	18.8	1.5	1.00	4.5	SAA		
MPD-18	07/27/96	1.00	15:10	0.28	1.28	1.84	30.62	18.7	1.8	1.250	4.4	SAA		
MPD-18	07/28/96	2.00	10:05	0.06	2.06	2.97	49.53	17.9	2.0	1.600	5.9	SAA		
MPD-18	07/28/96	2.00	15:55	0.31	2.31	3.32	55.37	17.6	2.2	1.800	5.6	SAA		
MPD-18	07/29/96	3.00	08:15	-0.01	2.99	4.30	71.70	16.7	2.6	2.300	8.9	SAA		
MPD-18	07/29/96	3.00	19:35	0.46	3.46	4.98	83.03	16.3	2.6	2.500	8.6	SAA		
MPD-18	07/30/96	4.00	08:25	-0.01	3.99	5.75	95.87	16.0	2.8	2.700	9.7	SAA		
MPD-18	08/05/96	10.00	11:10	0.11	10.11	14.56	242.62	9.3	3.4	2.400	10.0	SAA		
MPG-13	07/28/96	0.00	10:00	0.00	0.00	0.00	20.7	0.1	16	NS	1 min. purge	20.4888544	0	0.000217 0.013033
MPG-13	07/28/96	0.00	15:35	0.23	0.23	0.34	5.58	20.4	0.2	20	NS	17.9734954	11.58	
MPG-13	07/29/96	1.00	08:35	-0.06	0.94	1.36	22.58	20.0	0.8	40	NS			
MPG-13	07/29/96	1.00	19:47	0.41	1.41	2.03	33.78	20.0	1.1	52	NS	2 min purge		
MPG-13	07/30/96	2.00	08:50	-0.05	1.95	2.81	46.83	19.9	1.3	78	NS	Purged water for 1 min then purged soil gas for 1 min.		
MPG-13	08/05/96	8.00	11:00	0.04	8.04	11.58	193.00	18.0	2.8	34	NS	Purged water for 10 min then collected soil gas with Tedlar.		

VW2	07/26/96	0.00	08:40	0.00	0.00	0.00	20.8	0.05	26	0.10	5 min purge	20.3012265	0	0.000931 0.055835	
VW2	07/26/96	0.00	09:25	0.03	0.03	0.05	0.75	20.7	0.1	160	0.13	5 min purge	14.9410803	5.76	
VW2	07/26/96	0.00	12:00	0.14	0.14	0.20	3.33	20.1	0.5	460	0.82	10 min purge			
VW2	07/26/96	0.00	16:05	0.31	0.31	0.45	7.42	19.7	1.0	750	2.1	10 min purge			
VW2	07/27/96	1.00	09:30	0.03	1.03	1.49	24.83	18.6	1.7	1.350	4.2	10 min purge			
VW2	07/27/96	1.00	15:25	0.28	1.28	1.83	30.75	18.1	2.0	1.550	4.6	10 min purge			
VW2	07/28/96	2.00	10:25	0.07	2.07	2.98	49.75	17.1	2.5	1.800	6.5	10 min purge			
VW2	07/28/96	2.00	16:05	0.31	2.31	3.33	55.42	16.9	2.8	1.900	6.3	10 min purge			
VW2	07/29/96	3.00	08:30	-0.01	2.99	4.31	71.83	16.7	2.8	2.100	7.0	10 min purge			
VW2	07/29/96	3.00	19:30	0.45	3.45	4.97	82.83	16.0	3.0	2.200	8.6	10 min purge			
VW2	07/30/96	4.00	08:40	0.00	4.00	5.76	96.00	15.0	3.1	2.400	10.0	10 min purge			
VW2	08/05/96	10.00	11:35	0.12	14.58	242.92	14.0	3.4	2.600	6.3	5 min purge				

FORT CARSON-BUILDING 8200 - INITIAL

Biodegradation Rate Calculations

Formula:

$$K_b = K_o \times 1/100\% \times A \times D_o \times C \quad \text{Where:}$$

K_b = fuel biodegradation rate

K_o = O₂ utilization rate (%/min.)

A = volume of air/kg soil

D_o = O₂ density = 1340 mg/L

C = Carbon/O₂ ratio for hexane mineralization = 1/3.5

Solving for 1 L of soil:

Monitoring Point:

Oxygen util. rate

Moisture content ^{a/}

Soil Type ^{b/}

Porosity:

$$n =$$

$$g_d = G * g_w * (1-n) =$$

$$e = n/1-n =$$

$$G =$$

Deg. of saturation:

Volume of water:

Volume of air:

Bulk density:
A = V_a/Bulk Density

Void volume:

Deg. of saturation:

Volume of water:

Volume of air:

Air filled volume:

$K_b = K_o * 1/100\% * A * D_o * C * 525,600 \text{ min/yr}$

$K_b =$	84	mg TPH/ kg soil/ year
	40	70
		20

^{a/} Moisture:
^{b/} Assume:

For each monitoring point, the moisture value represents an average of three samples.

Soil properties are specified from Table 1.4. (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

VW2	%/min.	MPD-10	MPD-18	MPG-13
0.00093		0.00044	0.00077	0.00022
15.1	%	15.1	15.1	15.1

SILTY CLAY	SILTY CLAY	SILTY CLAY	SILT,CLAY
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n =	0.35	0.35	0.35
	1.72	1.72	1.72
	0.54	0.54	0.54
	2.65	2.65	2.65

liters	liters	liters	liters
0.35	0.35	0.35	0.35
0.74	0.74	0.74	0.74
0.26	0.26	0.26	0.26
0.09	0.09	0.09	0.09

kg/l soil	kg/l soil	kg/l soil	kg/l soil
2	2	2	2

0.045	0.045	0.045	0.045
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APPENDIX B
O&M CHECKLIST

**DATA COLLECTION SHEET
REGENERATIVE BLOWER SYSTEM
BUILDING 8200
FORT CARSON, COLORADO**